

DOCUMENT RESUME

ED 209 489

CE 030 513

AUTHOR Linhardt, Richard E.; Burhce, Steve
TITLE Agricultural Structures, Volume II.
INSTITUTION Missouri Univ., Columbia. Dept. of Practical Arts and Vocational-Technical Education.; Missouri Univ., Columbia. Instructional Materials Lab.
SPONS AGENCY Missouri State Dept. of Elementary and Secondary Education, Jefferson City. Div. of Career and Adult Education.
REPORT NO AG-91-I; Agdex-710
PUB DATE Jun 81
NOTE 557p.; For a related document see ED 203 141.
AVAILABLE FROM Instructional Materials Laboratory, University of Missouri-Columbia, 10 Industrial Education Bldg., Columbia, MO 65201 (\$20.00).
EDRS PRICE MF02 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Agricultural Education; Agricultural Skills; Behavioral Objectives; Building Plans; *Construction (Process); Construction Materials; *Electricians; Electricity; Energy; *Engineering Drawing; Grains (Food); Harvesting; Instructional Materials; Learning Activities; *Masonry; Plumbing; Secondary Education; Solar Radiation; Teaching Guides; *Vocational Education
IDENTIFIERS *Cement; Missouri

ABSTRACT

This guide to a curriculum unit in agricultural structures is designed to expand the curriculum materials available in vocational agriculture in Missouri. It and Agricultural Structures I (see note) provide reference materials to systematize the curriculum. The six units cover working with concrete (19 lessons, 2 laboratory exercises), drawing and plan reading (6 lessons), planning grain-feed handling (6 lessons), electrical work on the farm (14 lessons), plumbing on the farm (5 lessons, 1 laboratory exercise), and alternate energy systems (6 lessons). Each lesson may contain some or all of the following: an objective; study questions; references; teaching procedure with assignment; discussion; and answer key to examination; examination; transparency masters; assignment sheets; and handouts. Laboratory exercises may contain some or all of the following: objective, tools and materials needed, procedures, transparency masters, and handouts. A bibliography is found at the beginning of the guide. Appendixes include a listing of additional supplementary sources and cross indexing of the electrical work unit to the revised version of "Practical Farming Wiring Demonstrations," by Curtis Weston. (YLB)

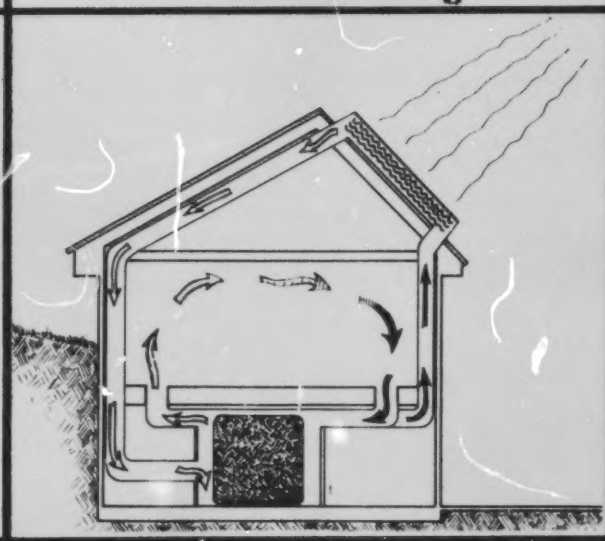
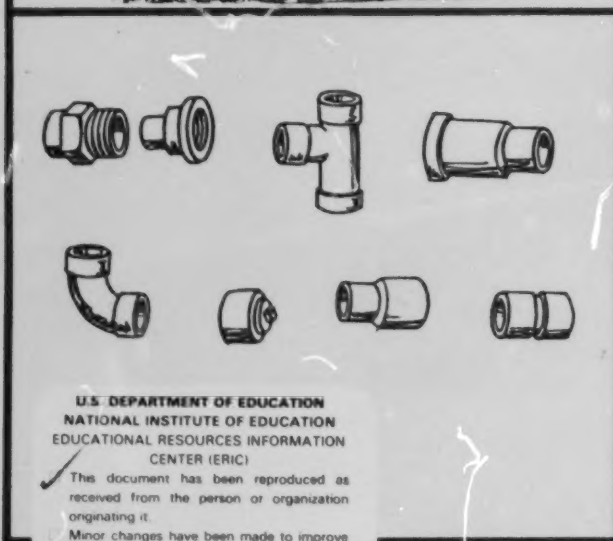
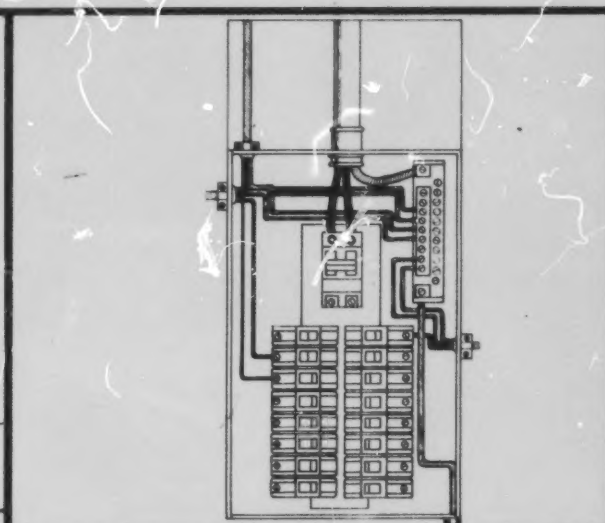
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Agricultural Structures

Volume II



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PRACTICAL ARTS
AND
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UNIVERSITY OF MISSOURI-COLUMBIA

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"The activity which is the subject of this report was supported in whole or in part by funds from the Department of Elementary and Secondary Education, Division of Career and Adult Education. However, the opinions expressed herein do not necessarily reflect the position or policies of the Missouri Department of Elementary and Secondary Education or the Division of Career and Adult Education, and no official endorsement should be inferred."

AGRICULTURAL STRUCTURES
Volume II

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Volume 13
Number 9

Produced by the Instructional Materials Laboratory
University of Missouri-Columbia
Columbia, Missouri

Catalog Number AG-91-I
June 1981

ACKNOWLEDGEMENTS

Many individuals have contributed guidance on the content to be included in a structures unit. The MVATA Teaching Aids Committee suggested the general content of the units, and the Structures Subcommittee helped to finalize the lessons to be included in each unit.

The Agricultural Engineering Extension Division was extremely helpful in locating reference materials with special emphasis going to the Midwest Plan Service. Together with AAVIM, the MWPS materials provided the bulk of the reference materials.

Special recognition is due to Dr. Harley Schlichting, Director of the Instructional Materials Laboratory, and his staff for the typing, editing and illustrating of this guide.

FOREWORD

This curriculum unit in Agricultural Structures is an important addition to the curriculum materials available in Vocational Agricultural. This unit has been a high priority item to help expand the Agricultural Structures course currently being taught in Missouri agriculture programs.

Teachers should make every effort to keep the lessons "practical" to help students understand and become proficient in the areas of agricultural structures.

This guide and Agricultural Structures I will provide valuable reference material to systematize the structures curriculum.

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AGRICULTURAL STRUCTURES
VOLUME II

TABLE OF CONTENTS

	PAGE
ACKNOWLEDGMENTS.	iii
FOREWORD	v
BIBLIOGRAPHY	xv
UNIT: WORKING WITH CONCRETE	1
LESSON 1: WHAT ARE THE MATERIALS USED IN CONCRETE AND HOW DID THEY EVOLVE TO THEIR PRESENT COMPOSITION?	1
LESSON 2: WHAT ARE THE PROPORTIONS OF MATERIALS IN A CONCRETE MIX?	7
LESSON 3: HOW IS THE CONCRETE SLAB LOCATION PREPARED BEFORE PLACING?	17
LESSON 4: HOW IS THE CONCRETE SLAB SURFACE FINISHED?	25
LESSON 5: WHY AND HOW ARE CONCRETE SLABS CURED?	35
LESSON 6: HOW DO YOU ESTIMATE THE QUANTITY OF MATERIALS NEEDED TO COMPLETE A CONCRETE JOB?	41
LESSON 7: WHAT CONCRETE FORMS ARE CONSTRUCTED ON THE FARM?	53
TM-1: Wall Forms.	61
LESSON 8: WHAT ARE THE REASONS AND METHODS FOR PLACING AND REINFORCING CONCRETE?	63
HO-1: Reinforcing Table	71
LESSON 9: WHAT ARE THE CAUSES OF CONCRETE SURFACE DEFECTS AND HOW ARE THEY PREVENTED FROM OCCURRING?	73
TM-1: Scaling Causes and Preventions.	81
TM-2: Cracking Causes and Preventions.	83
TM-3: Dusting Causes and Preventions.	85
LESSON 10: WHAT METHODS ARE AVAILABLE TO PRODUCE SLIP- RESISTANT CONCRETE FLOORS?	87
TM-1: New Floor Roughening	93
TM-2: Hardened Floor Roughening.	95
LESSON 11: WHAT IS CONCRETE MASONRY?	97
TM-1: Masonry Construction	105

LESSON 12:	WHAT BUILDING LAYOUT IS NEEDED FOR A BLOCK BUILDING FOUNDATION?	107
TM-1:	Layout	111
LESSON 13:	HOW ARE THE FOOTINGS CONSTRUCTED FOR BLOCK BUILDINGS?	113
TM-1:	Footing.	121
LESSON 14:	HOW IS THE MORTAR MIXED FOR CONCRETE MASONRY?	123
LESSON 15:	HOW IS THE FIRST COURSE OF BLOCKS CONSTRUCTED?	131
TM-1:	Mortar Bed	135
TM-2:	Buttering Block.	137
TM-3:	Side Alignment	139
TM-4:	Grade.	141
TM-5:	Plumb.	143
LESSON 16:	HOW ARE THE CORNERS OF A BLOCK BUILDING CONSTRUCTED?	145
TM-1:	Four-Course Corner	149
TM-2:	Course-Pole.	151
TM-3:	Horizontal Spacing	153
LESSON 17:	HOW ARE THE BLOCKS LAID BETWEEN CORNERS?	155
TM-1:	Mason's Line	161
TM-2:	Block-Wall Placement	163
TM-3:	Closure Block.	165
LESSON 18:	WHY AND HOW ARE MORTAR JOINTS TOOLED?	167
TM-1:	Jointer's Tools.	171
TM-2:	Tooling Horizontal Joint	173
TM-3:	Tooling Vertical Joint	175
LESSON 19:	WHAT SPECIAL APPLICATIONS ARE IMPORTANT TO CONCRETE MASONRY?	177
TM-1:	Anchor Bolt.	183
TM-2:	Masonry Wall Needs	185
LABORATORY EXERCISE.		187
HO-1:	Block Corner	192
LABORATORY EXERCISE.		193
TM-1:	Concrete Beam Tester	197
TM-2:	Concrete Beam Form	199
UNIT: DRAWING AND PLAN READING.		201
LESSON 1:	WHAT INSTRUMENTS ARE USED TO DRAW PLANS?	201
TM-1:	Pencils	207
TM-2:	Instruments	209
TM-3:	Scales.	211

LESSON 2:	WHAT BASIC PROCEDURES ARE IMPORTANT TO MECHANICAL DRAWING?	213
TM-1:	Set Up.	221
TM-2:	Lines	223
TM-3:	Labeling.	225
TM-4:	T and 45° Triangle.	227
TM-5:	T and 60° Triangle.	229
TM-6:	T and Both Triangles.	231
LESSON 3:	HOW ARE THE LETTERS AND NUMBERS DRAWN ON THE WORKING PLAN?	233
TM-1:	Making Letters.	241
TM-2:	Making Numbers.	243
HO-1:	Making Letters.	245
HO-2:	Making Numbers.	246
LESSON 4:	WHAT ARE THE WAYS TO VIEW A PROJECT THROUGH WORKING DRAWINGS?	247
TM-1:	Isometric Drawing	255
TM-2:	Oblique Drawing	257
TM-3:	Orthographic Drawing.	259
TM-4:	Cross-sectional Drawing	261
LESSON 5:	WHAT IS THE CORRECT METHOD FOR READING A PLAN?	263
TM-1:	Dimensions.	271
TM-2:	Building Materials.	273
TM-3:	Plumbing and Heating.	275
TM-4:	Electrical Symbols.	279
LESSON 6:	HOW IS THE BILL OF MATERIALS DETERMINED IN A PROJECT?	281
TM-1:	Plan.	287
TM-2:	Material List	289
TM-3:	Cutting List.	291
UNIT:	PLANNING GRAIN-FEED HANDLING.	321
LESSON 1:	INTRODUCTION TO GRAIN-FEED HANDLING STRUCTURES.	321
TM-1:	Prior Planning.	325
LESSON 2:	WHAT IS A CLOSED-LOOP HANDLING SYSTEM?	327
TM-1:	Components of Grain System.	333
TM-2:	Options for Grain Systems	335
TM-3:	Use of Horizontal Conveyors	337
TM-4:	Hopper Use.	339
TM-5:	Inclined Conveyor	341

LESSON 3:	WHAT ARE THE FLOW PRINCIPLES AFFECTING GRAIN-FEED HANDLING?	343
TM-1:	Gravity Versus Conveyor	351
TM-2:	Systems Comparison.	353
HO-1:	Bin Types, Sizes, and Uses.	355
LESSON 4:	HOW ARE HANDLING COMPONENTS MATCHED?	357
HO-1:	Motor Controls for Conveyors in Sequence.	365
LESSON 5:	WHAT ARE THE COMPONENTS OF FARM-MATERIALS FLOW?	367
TM-1:	Equipment Alternatives for Each Flow Function	375
LESSON 6:	HOW ARE STORAGE METHODS EVALUATED?	377
TM-1:	Bin Drying.	385
TM-2:	Batch and Continuous.	387
TM-3:	Cooling Grain	389
TM-4:	Treating Grain.	391
UNIT:	ELECTRICAL WORK ON THE FARM	393
LESSON 1:	WHAT ARE THE COMPONENTS OF ELECTRICAL SAFETY INSTRUCTION?	393
HO-1:	Terms Associated With Wiring Buildings.	405
LESSON 2:	WHAT ARE THE GROUND-FAULT CIRCUIT-INTERRUPTERS AND HOW ARE THEY APPLIED TO FARM STRUCTURES?	409
TM-1:	The GFCI.	415
TM-2:	Three Types of GFCI's	417
LESSON 3:	WHAT ARE THE GRAPHICAL ELECTRICAL SYMBOLS FOR FARM WIRING PLANS?	419
TM-1:	Electrical Symbols #1	427
TM-2:	Electrical Symbols #2	429
LESSON 4:	IDENTIFYING WIRE TYPES AND SIZES USED IN FARM WIRING.	431
HO-1:	Copper and Aluminum Loads and Sizes, Weights and Resistances of Conductors	439
HO-2:	Loss Evaluation and Wire-Size Selection Chart	440
LESSON 5:	WHAT ARE THE GENERAL REQUIREMENTS TO CONSIDER WHEN CONSTRUCTING A FARM STRUCTURE?	441
LESSON 6:	WHAT ARE THE FACTORS TO CONSIDER WHEN PLANNING THE ELECTRICAL NEEDS OF FARM STRUCTURES?	449
TM-1:	Dairy Needs	459
TM-2:	Hog Needs	461
TM-3:	Farm Shop Needs	463

LESSON 7:	HOW ARE THE WIRING NEEDS FOR A FARM BUILDING CALCULATED BY THE BUILDER?	465
HO-1:	Farm Shop	473
HO-2:	Dairy Barn.	475
HO-3:	Wire Tables	477
HO-4:	Computing Electrical Service Needs For Your Home.	479
LESSON 8:	HOW ARE THE SIZES OF THE FEEDER WIRES DETERMINED FOR THE FARM BUILDING?	481
HO-1:	Feeders	487
HO-2:	Tables.	489
HO-3:	Example 1, 1a, 2.	495
HO-4:	Example 3, 3a	496
HO-5:	Computing Farm Loads NEC.	497
HO-6:	Feeder Load NEC	499
LESSON 9:	HOW ARE THE POWER LINES CONNECTED TO THE BUILDINGS AND HOW ARE FARM BUILDINGS WIRED BY THE NEC	501
LESSON 10:	HOW IS THE WIRING CONNECTED TO THE SERVICE ENTRANCE PANEL (SEP)?	511
TM-1:	Panel Parts.	519
TM-2:	Wired Panel.	521
TM-3:	Ground System.	523
TM-4:	Wired Panel 120/240V	525
LESSON 11:	HOW ARE WIRES RUN FROM THE SERVICE ENTRANCE PANEL TO THE OUTLETS?	527
TM-1:	Floor Plan	535
TM-2:	Wiring Plan.	537
TM-3:	Labeling	539
TM-4:	Ceiling Runs	541
TM-5:	Wires to Outlets	543
LESSON 12:	WHAT ARE THE PRINCIPLES OF WIRING SWITCHES AND CIRCUITS?	545
LESSON 13:	HOW IS ELECTRICAL POWER AND COST CALCULATED ON THE FARM?	557
TM-1:	Formulas	565
TM-2:	Meter Reading.	567
LESSON 14:	PROTECTING THE FARMSTEAD FROM LIGHTNING. . .	569
TM-1:	How Lightning Strikes.	579
TM-2:	Lightning Protection Devices	581
TM-3:	Recommended Grounding Practices for Buildings	583
TM-4:	Recommended Grounding Practices for Waterers	585
HO-1:	Recommended Grounding Practices.	587

UNIT: PLUMBING ON THE FARM.	589
LESSON 1: WHAT SAFETY PRACTICES NEED TO BE FOLLOWED WHEN INSTALLING OR EXPANDING PLUMBING SYSTEMS? . . .	589
LESSON 2: WHAT EQUIPMENT AND SUPPLIES ARE NEEDED TO INSTALL OR REPAIR AN ON-FARM WATER SYSTEM? . .	595
TM-1: Plumbing Tools #1	601
TM-2: Plumbing Tools #2	603
TM-3: Plumbing Tools #3	605
LESSON 3: WHAT ARE THE TYPES OF PIPE AND FITTINGS USED IN FARM PLUMBING?	607
TM-1: Copper and Plastic Fittings	615
TM-2: Cast Iron Pipe and Fittings	617
TM-3: Cast-Iron and Steel Fittings.	619
TM-4: Expansion and Contraction of Piping	621
HO-1: Summary of Comparisons Among Pipe Types . . .	623
HO-2: Plastic Pipe Materials.	624
LESSON 4: HOW ARE PIPES MEASURED, CUT AND JOINED TOGETHER WHEN CONSTRUCTING A PLUMBING SYSTEM? .	625
TM-1: Table of Fitting Dimensions	639
LESSON 5: HOW ARE WATER PIPES PROTECTED FROM FREEZING? .	641
TM-1: Laying Water Pipe and Installing Frost-Proof Hydrants.	647
TM-2: Heating Pipe.	649
LABORATORY EXERCISE.	651
UNIT: ALTERNATE ENERGY SYSTEMS.	665
LESSON 1: WHICH ENERGY SYSTEMS ARE CURRENTLY BEING USED AND WHAT IS COMING IN THE FUTURE? . . .	665
TM-1: Present Use of Energy	671
TM-2: Alternate Sources	673
LESSON 2: WHAT ARE THE BASIC SOLAR PRINCIPLES THAT APPLY TO AGRICULTURAL BUILDING PLANNING AND CONSTRUCTION?	675
TM-1: Sun Path.	683
TM-2: Parts of a Solar System	685
HO-1: Definition of Terms	687
LESSON 3: WHAT ARE THE PASSIVE SOLAR SYSTEMS AND CONCEPTS?	689
TM-1: Passive Systems	697

LESSON 4:	WHAT ARE ACTIVE SOLAR SYSTEMS AND THEIR CONCEPTS?	699
TM-1:	Water Collector and Concentrators	707
TM-2:	Air Collector	709
HO-1:	Efficiencies and Absorption	711
HO-2:	Design Tips - Alternate Energy.	712
LESSON 5:	WHAT ARE SOME OTHER SOURCES OF ENERGY FOR THE FARM STRUCTURES?.	713
LESSON 6:	HOW IS METHANE GAS GENERATED FROM MANURE? . .	723
TM-1:	Methane Process	731
TM-2:	Anaerobic Digester.	733
HO-1:	Gas Production.	735
HO-2:	Gas Needs	736
APPENDIX A		745
APPENDIX B		747

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UMC Guides are available from Extension Information, 98 Agriculture Building, Columbia, MO 65211.

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2. "Computing Electrical Service Needs for Your Home," Extension Bulletin, #1760, UMC.
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SLIDE-TAPE SETS

1. Slide-Tape Set, Concrete Placing, Finishing and Curing Flat Slabs. by Fred Venrick, Instructional Materials Laboratory, University of Missouri-Columbia, Columbia, MO 65211. \$55. (Slides 1-16)
2. Slide-Tape Set, Concrete - Materials Proportioning, by Fred Venrick available through Instructional Materials Laboratory, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211. Cost - \$55 (Slides 33-80)

UNIT - WORKING WITH CONCRETE

Lesson 1 - What are the materials used in concrete and how did they evolve to their present composition?

Objective: By the conclusion of the lesson, the student will be able to list the raw material components of concrete, and trace through history the development of present-day concrete.

Study Questions:

1. What is concrete?
2. Where is concrete used today?
3. What are the major components of concrete?
4. What is the history of Portland cement and concrete?
5. What are the types of Portland cement and how is the quality controlled?

References:

1. Concrete and Concrete Masonry. Hobar Publications, available through Instructional Materials Laboratory, 10 Industrial Education Building, University of Missouri-Columbia, Mo. 65211. \$4.95 singles, \$4.00 over 10.
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UNIT - WORKING WITH CONCRETE

Lesson 1 - What are the materials used in concrete and how did they evolve to their present composition?

TEACHING PROCEDURE

A. Review

B. Motivation - Discuss structures made of concrete. Cite examples from the community. Ask if anyone has ever helped place concrete for a slab. What goes into a good concrete mix? Are all concrete mixes the same?

C. Assignment - Identify structures around the farm that have concrete in them.

D. Supervised Study

E. Discussion

1. The advantages of concrete are known to be its strength and durability. What is it really?

What is concrete?

- 1) A versatile construction material
- 2) "The stone you can mold"
- 3) Low maintenance costs
- 4) A hand-building material made of sand, gravel, cement and water

2. List on the board or a transparency as many structures made of concrete as you can. Discuss with the class other applications.

Where is concrete used today?

- 1) Anywhere strength and durability are needed
- 2) School overpasses
- 3) Columns to support bridges or buildings
- 4) Highways
- 5) Airports (asphalt can dissolve if fuel is spilled on it)
- 6) Feedlots

3. To get a strong finished product you must combine the right ingredients. What goes into a concrete mix? What might happen if an ingredient is left out? List the ingredients on the board or a transparency.

What are the major components of concrete?

- 1) Aggregates
 - a) Sand - clean
 - b) Gravel or stone - clean, moderate size
- 2) Water - clean and pure
- 3) Cement - bonding agent
- 4) Air - for air-entraining qualities discussed later
- 5) Cement made from:

Limestone + Cement rock	Clay + Shale	
Oyster shells + Coquina +	Silica sand + Iron ore	= Clinker
Marl Shells + Marl from rivers		

Clinker + Gypsum = Portland Cement

- 6) Portland cement patented in 1824 by Joseph Aspdin
- 7) Combination of calcareous (limelike) and argillaceous (claylike)

4. Cement is not a new innovation to the world. It can be traced back through history to cave men who used the clay from rivers to fill cracks in stone. What ancient structures still standing today have cement in their construction? Prepare a bulletin board to trace the history of cement.

What is the history of Portland cement and concrete?

- 1) Cave men used clay to fill cracks between stones and found it added strength.
- 2) Assyrians and Babylonians used a lime-clay mix for wall construction around cities.
- 3) Egyptians added gypsum for more strength.
- 4) Egyptians found by adding limestone chips and just, strength improved more.
- 5) Romans used lime and volcanic ash which had considerable binding qualities.
- 6) Cement (the word) was derived from:
 - a) Caedo (Kido) Latin - strike or chip, Caementum
 - b) Seedo in English, Seementum
- 7) Concrete from concretus - which means grown together
- 8) 18th and 19th Century engineers in Europe and England tried burning and mixing elements to produce cement
- 9) Joseph Aspdin in 1824 used ground limestone from the streets plus water and clay which was then burned; the product mixed with water resembled stone from the Isle of Portland.

10) David O. Saylor first made Portland cement in the U.S. in 1874 in Pennsylvania.

5. With the changes in structure and uses of buildings, the types of concrete needed changing also. Why would there be a need for different types of concrete?

What are the types of Portland cement and how is the quality controlled?

- 1) Type I is general purpose (normal) cement used in pavement and sidewalks, reinforced buildings, tanks.
- 2) Type IA is general purpose (normal) air-entrained cement having cold-weather tolerance.
- 3) Type II is modified Portland cement where sulfate or heat build-up is a problem. Bridge supports, pilings, retaining walls.
- 4) Type III is high, early-strength cement when strength is needed in one to three days. Bridges, winter building, fast removal of forms
- 5) Type IIIA is air-entrained.
- 6) Type IV is low-heat cement.
- 7) Type V is sulfate-resistant.
- 8) Two agencies write specifications that control quality:
 - a) ASTM - American Society for Testing and Materials
 - b) CSA - Canadian Standards Association

F. Summary

Concrete is a very versatile building material with a long and famous history. Over the years the uses have been similar and the components refined but the basic composition has been basically unchanged.

G. Evaluation

Answers to the Exam

1. Aggregates of
 - a. Sand
 - b. Gravel
 - c. Cement
 - d. Water
2. Joseph Aspdin
3. General purpose
4. a. American Society for Testing and Materials
b. Canadian Standards Association
5. David O. Saylor

UNIT - WORKING WITH CONCRETE

Lesson 1 - What are the materials used in concrete and how did they evolve to their present composition?

EXAM

1. List four raw materials found in concrete.

a.

b.

c.

d.

2. Who was the father of Portland cement?

3. What is a use of Type IA Portland cement?

4. What do these letters stand for?

ASTM - _____

CSA - _____

5. Who introduced Portland cement to the U.S.?

UNIT - WORKING WITH CONCRETE

Lesson 2 - What are the proportions of materials in a concrete mix?

Objective: By the conclusion of the lesson, the student will be able to discuss component quality, recall Abrams' Law, mix a batch of concrete, and conduct a slump test.

Study Questions:

1. What component quality factors need to be considered when selecting the parts of the concrete mix?
2. Why is aggregate shape and size important?
3. Why is air-entraining important in concrete?
4. What is Abrams' Water-Cement Ratio Law and why is it important?
5. How is a demonstration mix properly proportioned?
6. Why should concrete mixes be slump tested and how is it done?

References:

1. Concrete and Concrete Masonry, by Donald L. Ahrens, Hobar Publications, Division of Hobar Enterprises, Inc., 1305 Tiller Ave., St. Paul, Minnesota 55112, available through Instructional Materials Laboratory, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, Mo. 65211. \$4.95 single, \$4.00 over 10.
2. Slide-Tape Set, Concrete - Materials Proportioning, by Fred Venrick, available through Instructional Materials Laboratory, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, Mo. 65211. Cost \$55. (Slides 33-80).

UNIT - WORKING WITH CONCRETE

Lesson 2 - What are the proportions of materials in a concrete mix?

TEACHING PROCEDURE

- A. Review the major components of the concrete mix: aggregates, water, cement, air.
- B. Motivation - How do we know how much of each of the components to add to the mix? Do the components have to be clear? Why? Why not? What will water do to a mix if too much is added?
- C. Assignment
- D. Supervised Study - In the classroom have examples of each of the components and samples of aggregates in large and small sizes. Mix small batches and check at various stages of hardness. Compression test the mixes in the shop if facilities exist.
- E. Discussion
 1. When selecting components do not purchase or use low-grade materials to save money; they will usually end up costing you more in the end. How do you tell good from bad quality components?

What quality factors need to be considered when selecting the parts of the concrete mix?

 - 1) Mixing water needs to be free of acids, alkalis, oil, or sulfates.
 - 2) Aggregates free of silt, clay, chemicals
 - 3) Aggregates must be hard, durable particles
 - 4) Two main groups of aggregates
 - a) Fine - sand (through a No. 4 screen)
 - b) Coarse - gravel, crushed rock
 - 5) Natural aggregates must be washed and screened before being used
 - 6) An unsuitable aggregate contains twigs, dirt and other organic matter that will affect the hardening process
 - 7) If aggregate contains measurable silt it should be washed or discarded; test using jars of water and aggregate
 2. The shape and size of aggregate is important when trying to restrict surface area of stone to be covered. Which aggregate shape has more surface area - a cubic-inch square or a cubic-inch rectangle 4 inches long? (Answer: The rectangle which is 10 1/2 sq. in. compared to the square which is 6 sq. in.)

Why is aggregate shape and size important?

- 1) Elongated pieces of aggregate take more paste to cover their surfaces.
 - 2) A cube 1 inch by 1 inch requires 75% less paste to cover its surfaces than a rectangle 1/4 by 1 by 4 inches. They both displace 1 cubic inch.
 - 3) Light-weight concrete (85 to 115 pounds per cubic foot) uses expanded clay, shale, slate or slag aggregates.
 - 4) Common concrete (135 to 160 pounds per cubic foot) uses sand, gravel and crushed stone.
 - 5) If reinforcing is used in the slab, maximum aggregate size should not exceed 1/5 of narrowest dimension or 3/4 of the clear spacing between bars or in unreinforced slabs 1/3 the slab thickness.
 - 6) A 16% void space is considered optimum for an aggregate mix.
 - 7) Do not use all large aggregate; fill the large voids with smaller aggregate; aggregate should be 60 to 80 percent of the fill.
3. In the 1930's it was found that concrete quality could be improved by entraining air. Type A Portland mixtures contain entrained air. Why is this important?

Why is air entraining important in concrete?

- 1) Type A Portland cement (ASTM) contains entrained air qualities automatically.
- 2) An air-entraining agent may be added at mixing to produce air-entrained concrete
- 3) Bubbles are very small, one to three thousandths of an inch in diameter.
- 4) One cubic foot of concrete with 4 to 6 percent air entrainment will contain 11 to 18 billion bubbles
- 5) One of the greatest benefits is that it improves the concrete's resistance to freezing and thawing damage.
- 6) In fresh concrete air entraining improves:
 - a) Work ability
 - b) Reduces segregation
 - c) Reduces "water bleeding"
 - d) Finishes sooner
 - e) Reduces required sand content
 - f) Reduces water needs 3-5 gallons per cubic yard
- 7) In hardened concrete air entraining increases:
 - a) Freeze-thaw resistance
 - b) Resistance to salt action
 - c) Resistance to sulfate action
 - d) Watertightness improves

4. What is the proper mix of water and cement?
Does it matter if you add just a little more water to make the concrete easier to place?

What is Abrams' Water-Cement Ratio Law and why is it important?

- 1) Published in 1918 from the Lewis Institute in Chicago
- 2) Abrams' Law, "With given concrete materials and conditions of test, the quantity of mixing water used determines the strength of the concrete, so long as the mix is of a workable plasticity."
- 3) Research has established the principle; the ratio dictates:
 - a) Conditions of handling
 - b) Strength
 - c) Watertightness
 - d) Durability
- 4) Maximum water - cement ratio for a slab is 6 gallons of water per 94 pound sack of cement or 53 pounds of water per 100 pounds of cement
- 5) The cementing properties are due to hydration (chemical reactions between water and cement).
- 6) Not all water is needed for hydration; the extra water is used for workability and plasticity.
- 7) If the water - cement ratios are increased, (more water added than is actually needed) the water not needed will evaporate leaving voids in the concrete.
- 8) These voids decrease:
 - a) Strength
 - b) Watertightness
 - c) Durability
 - d) Compression strength
- 9) A 6 gallon per sack mix has compression strength at 28 days of 4,000 pounds per square inch; add one gallon more to the mix (increase of 16.7% to the ratio) and strength decreases 17.5% to 3300 pounds per square inch.

5. How are the concrete components mixed together?
What determines the proportions? Mix a demonstration mix in class to determine how to proportion and calculate the needs of a mix.

How is a demonstration mix properly proportioned?

- 1) To demonstrate a 6 gallons of water per sack mix make a 1/16 sack mix. An 8 ounce cup can be used to equal 1 gallon of water in a full mix and 1/16 of a sack is 5 7/8 pounds of cement.
- 2) Gather the following tools and ingredients:

- a) Cement
 - b) Water
 - c) Sand
 - d) Coarse aggregate
 - e) Mixing pan
 - f) Blunt-nosed trowel
 - g) Scales
 - h) 8 ounce measuring cup
- 3) If the sand is wet one must calculate how much water is in the sand.
 - a) If the sand when compressed by hand falls apart when released, it is damp. Subtract 1/2 gallon of water from a 6 gallon mix.
 - b) If the sand balls and holds shape, it is average wet. Subtract 1 gallon water per sack.
 - c) If the sand sparkles and leaves the hand wet, it is very wet. Subtract 1 1/2 gallons water.
 - 4) Add only enough sand and aggregate to make the work plastic and workable; too much is difficult to final finish.
 - 5) First mix the dry sand and cement together.
 - 6) Make a crater in the center and add all the water; mix thoroughly.
 - 7) Add coarse aggregate slowly, working it in until the mix is workable and will give a maximum yield from the cement (60-70% aggregate).
6. To test the consistency of the concrete mix, often a slump test is used. It is an approved method of checking that the water-cement ratio is proper.

Why should concrete mixes be slump tested and how is it done?

- 1) Test of consistency made according to Standard Test Method for Slump of Portland Cement Concrete. (ASTM C143)
- 2) A special conical-shaped slump mold and a metal-tamping rod are needed.
- 3) The mold is 12" high, top 4" in diameter, bottom 8" in diameter.
- 4) The rod is round, straight steel rod 5/8" in diameter and 24" long
- 5) Mold should be moistened and placed on a flat, moist, rigid surface
- 6) Fill in three equal levels, tamping after each addition 25 times.
- 7) Fill over the top of the mold and strike off the excess.

- 8) Raise the mold and place the mold next to the slumped concrete.
- 9) Measure the difference from the top of the mold to the height of the slumped concrete. Slump of 3 to 4 inches is acceptable for medium consistency concrete.

F. Summary

The key to a good mix is to add enough of the lower priced aggregate to make the mix economical but still have the strength needed. The mixture needs to be workable and plastic, and the proportions such that the slab can be easily finished to a smooth surface.

G. Evaluation

Answers to the Exam

1. F
2. T
3. F
4. T
5. T
6. a. Water
b. Cement
7. hydration
8. 1 (one)
9. Refer to study question 6

UNIT - WORKING WITH CONCRETE

Lesson 2 - What are the proportions of material in a concrete mix?

EXAM

- T F 1. Organic matter in the aggregate adds strength to mix?
- T F 2. Silt content can be determined by a jar wash test.
- T F 3. Large rectangular flat stone aggregate is preferred because it fills spaces faster than smaller stone.
- T F 4. A 16% void between aggregate is the recommended aggregate spacing.
- T F 5. Air entraining has the properties needed to resist freezing and thawing.
6. Abrams' Law deals with the ratio of which two components of concrete.
- a.
- b.
7. The chemical action that causes concrete to harden is called _____.
8. If sand is judged to be average wet, _____ gallons of water per sack should be subtracted.
9. How is the slump test performed?

UNIT - WORKING WITH CONCRETE

Lesson 3 - How is the concrete slab location prepared before placing?

Objective: By the conclusion of the lesson, the student will be able to prepare the slab site subgrade, check the slope of the slab, install the slab forms, accurately check the slope of the forms, plan for thickened edges and install expansion-joint material.

Study Questions:

1. What subgrade preparation is needed before placing a concrete slab?
2. How is the slope of the slab determined?
3. How are slab forms constructed?
4. How is the slope of the forms determined?
5. Where is slab thickness increased and expansion-joint material used in slab construction?

References:

1. Concrete and Concrete Masonry, Hobar Publication available through Instructional Materials Laboratory, University of Missouri-Columbia, Columbia, MO. 65211. \$4.95, \$4.00 over 10.
2. Slide-Tape Set, Concrete Placing, Finishing and Curing Flat Slabs. by Fred Venrick, Instructional Materials Laboratory, University of Missouri-Columbia, Columbia, Mo. 65211. #55. (Slides 1-16)

UNIT - WORKING WITH CONCRETE

Lesson 3 - How is the concrete subgrade prepared before placing?

TEACHING PROCEDURE

- A. Review the lesson on how water affects the quality of the mixes and how to perform a slump test.
- B. Motivation - Who in the class has ever laid out and prepared the ground for placing concrete?
How do you check the level of the land?
How are the forms installed? How do you prevent manure and water build-up on the surface?
- C. Assignment
- D. Supervised Study - If materials and facilities allow, level an area and set the forms needed to place a slab. If not, do some simple slope measurements with a builder's level or bubble level. Set up some soil compaction comparisons with dirt and aggregates.
- E. Discussion
 1. Is there any land preparation needed before pouring and finishing a concrete slab? How "perfect" does it have to be? What makes the best subgrade? List the steps as you proceed through the lesson.

What subgrade preparation is needed before placing a concrete slab?

- 1) For a standard unreinforced slab 4 to 6 inches thick
- 2) Need to be even and well compacted
- 3) Subgrade needs to have a uniform grade (slope)
- 4) Remove all organic materials.
- 5) A tractor and blade is used to prepare the subgrade.
- 6) If subgrade needs fill or has irregular surfaces, the tractor tires can be used to compact along with light crossgrading.
- 7) If fill is needed, use granular material and compact it.
- 8) Mechanical rollers (if available) can also be used effectively.

2. While preparing the subgrade, check the slope regularly to maintain uniformity.

How is the slope of the slab determined?

- 1) Check with a builder's or contractor's optical level.
- 2) Minimum slope should be 1/4-inch per foot in at least one direction.
- 3) Before setting the forms, use the level to place markers and lines to get slope desired.
- 4) The level can easily be used to set string lines.

3. What are the forms made of? How are they held in place? Draw out a slab square or rectangle to show the wood that is needed.

How are slab forms installed?

- 1) Side forms are set along the string line.
- 2) The forms are held in place by stakes driven on the outside of the side boards.
- 3) For a 4 inch thick slab, the stakes should be 8 to 10 inches long.
- 4) Drive the stakes well below the top of the side boards to allow for easy passage of the screed.
- 5) One inch thick stakes are heavy enough for the forms.
- 6) Nail the stakes to the side boards of the form with double-head nails from the outside in.

4. Once the forms have been roughly laid out, we need to know if the slope is still 1/4-inch per foot. If the forms are off, the slab will also be off.

How is the slope of the forms determined?

- 1) To check the level of the forms, use a mason's or carpenter's level.
- 2) To find or check the slope of the forms use a 4-foot level and a one-inch spacer block, checking if the level is level when the downhill side is supported by the block.
- 3) This gives a one-inch drop for four feet of level or 1/4-inch per foot.
- 4) The form can be adjusted to level the strike-off surface.
- 5) When checking slope across the form, lay a square board across the area to be filled resting one end on each side board and check as before.

- 6) The slab should be of uniform thickness. So, use a templet which rides the side forms to check the area within the forms.
5. To prevent deterioration of the edges of the slab to be laid, a thickened edge should be laid.

Where is slab thickness increased and expansion-joint material used in slab construction?

- 1) Thickened edges are used on the perimeter of feeding floors and driveway edges where livestock or vehicles enter the paved area.
- 2) The edge should measure 4 to 6 inches thicker than the slab, 12 inches wide at the base, and have a 45-degree slope from the bottom of the main slab to the bottom of the thickened edge.
- 3) If the slab butts up against another structure, use an expansion joint to separate.
- 4) The joint will allow the slab to move slightly without damaging the adjoining structure.

F. Summary

The preparation of the subgrade and setting of the forms will determine the quality of the finished product as much as the concrete itself. Without a grade, water and manure will not drain and without proper thickness the concrete could be weak and have a short life.

G. Evaluation

Answers to the Exam

1. T
2. a. Builder's optical level
b. Level set on forms
3. F
4. T
5. 6-foot length with a two-inch drop gives a slope of 1/3-inch per foot

UNIT - WORKING WITH CEMENT

Lesson 3 - How is the concrete slab location prepared before pouring?

EXAM

- T F 1. Most subgrades for a concrete slab can be prepared using a tractor and blade.
2. The slope of the slab can be checked by two methods, they are:
- a.
 - b.
- T F 3. The stakes for a four-inch slab must be 2" x 4" x 12" long to insure a strong form.
- T F 4. Thickened edges are used in areas of heavy traffic.
5. Problem: If you are checking the slope of a form with a six-foot mason's level and you have a two-inch drop at the end of level, what is the slope per foot?

UNIT - WORKING WITH CONCRETE

Lesson 4 - How is the concrete slab surface finished?

Objective: By the conclusion of the lesson, the student will be able to check ready mixed concrete for slump, check the concrete for percent air entrainment, identify a concrete mix for an exterior flat slab, prepare the forms to prevent bonding to them, check the concrete for workability, show two methods to prevent edge honeycombing, strike off the concrete, float the surface, check for "bleed water", cut control joints, and finish the surface.

Study Questions:

1. How is the slump of ready mixed concrete determined?
2. How is the air-entraining percentage determined?
3. What are the proportions of the concrete mix for an exterior flat slab?
4. How is the concrete kept from bonding to the forms?
5. How is concrete checked for workability? How are the edges kept from honeycombing?
6. What methods are used to strike off concrete?
7. How is the surface "floated"?
8. What is "bleed water" and its problems?
9. Why and how are control joints cut?
10. How is the surface finished?

References:

1. Concrete and Concrete Masonry, Hobar Publications, available through Instructional Materials Laboratory.
2. Slide-Tape Set, Concrete - Placing, Finishing and Curing Flat Slabs, Instructional Materials Laboratory. (Slides 16-76).

UNIT - WORKING WITH CONCRETE

Lesson 4 - How is the concrete slab finished?

TEACHING PROCEDURE

- A. Review Lesson 2 on how and why to do a concrete slump test.
- B. Motivation - While walking around the school, look at the concrete that has been placed and judge its quality of finish. Is it broken or chipped? Does the aggregate show on the surface or side? Are there cracks in the surface? Are the control joints set to the proper depth? Draw up a report on the condition of the concrete and discuss the report in class.
- C. Assignment - Locate a slab of concrete on each student's farm and prepare an in-depth analysis of the finished project. Have students relate possible problems or future problems with the slabs.
- D. Supervised Study
- E. Discussion
 1. Whether ordering ready mixed concrete or mixing your own, a consistency test should be made to check the proportioning of ingredients. How many tests should we run? Is it difficult to do a concrete slump test?

How is the slump of ready mixed concrete determined?

- 1) For ready mixed delivered loads, two or more samples should be taken for slump testing.
- 2) Combine the samples and mix together.
- 3) Slump test should be performed using the guideline set by American Society for Testing and Materials Method (ASTM).
- 4) Needed for slump test:
 - a) Mold - 12 inches high, 4-inch diameter top, 8-inch diameter bottom
 - b) Tamping rod - round, straight-steel rod 5/8-inch diameter, 24 inches long, one end rounded
- 5) Dampen the mold and place on flat, moist rigid surface.
- 6) Fill in three levels rodding the mixture 25 times after each layer.
- 7) Fill in excess of the mold capacity; then strike off the excess.
- 8) Raise the mold carefully.

- 9) Place the mold next to the slumped concrete and measure the difference between the height of the mold and the height of the slumped concrete; slump of 3 to 4 inches is preferred for slabs.
2. As was earlier explained, air entraining can help prevent cold weather damage of concrete. But, how is the amount of air entraining determined?

How is the air-entraining percentage determined?

- 1) Two methods approved by ASTM
 - a) Pressure method more accurate
 - b) Pocket-sized air indicator approximate
- 2) For very accurate field testing, use the pressure method except when aggregates are highly porous or light weight.
- 3) The pocket-sized air indicator is a glass container and a small stopper cup.
- 4) The procedure for use is:
 - a) Fill stopper cup with cement mortar paste. (no large aggregate, use a small knife blade)
 - b) Compact the mortar in the cup.
 - c) Hold finger over the stem opening of the glass container and fill to the line on the glass with isopropyl alcohol.
 - d) Insert the stopper cup into the large end of the glass container.
 - e) Invert and adjust liquid level to top mark on the stem.
 - f) Cover the small end of the tube and roll the container gently until the mortar is dissolved in the alcohol.
 - g) With indicator vertical, remove cover from small end and count number of spaces from top to new level.
 - h) If mix contains 15 cubic feet of mortar per cubic yard, the number will directly represent the approximate percentage of entrained air per cubic yard; if other than 15, use conversion chart supplied by manufacturer.
3. If you are ordering a ready mixed or mixing concrete yourself, what proportions do you ask for in a flat slab to be placed outdoors? What slump and entrainment should it have?

What are the proportions of an exterior flat slab?

- 1) Water - maximum 6 gallons/sack or 53#/100# cement
- 2) Cement - minimum 6 sacks or 564#/cubic yard
- 3) Slump - maximum 4 inches
- 4) Entrained air - 5% to 7%

4. After the forms are constructed and before the concrete is placed, precautions must be taken to prevent bonding to the wood or metal forms.

How is the concrete kept from bonding to the forms?

- 1) Coat the inside of the boards with light weight engine oil.
- 2) Curing compound, if it is to be used later, will also prevent sticking.
- 3) Immediately before pouring and after treating the forms, thoroughly wet the subgrade to prevent the subgrade from pulling moisture out of the concrete.

5. Check the batch of concrete for workability before placing. Be sure it is workable and plastic.

How is concrete checked for workability and the edges kept from honeycombing?

- 1) Discharge a small amount before placing and check the workability with a trowel or float.
- 2) A smooth surface is evidence of plasticity and workability.
- 3) After placing into the mold to capacity, (top on the side and end boards) use a shovel to spade between the boards and poured concrete.
- 4) Spading will prevent edge "honeycombing".
- 5) Spading also makes edging easier.
- 6) Another method is to hit the outside of the forms with a rubber hammer to consolidate the concrete.

6. The first finishing step after placing the concrete is striking off. Various methods are used, but the key is to have the forms full but not overflowing to cut future work troubles.

What methods are used to strike off concrete?

- 1) Use a 2 x 4 or 2 x 6 that will reach from one side board to the other.
- 2) Move the board back and forth and forward maintaining a small roll of concrete ahead of the board to prevent voids.
- 3) If labor is available, use a three-man-screed with a person on each end by the side boards and one person pulling the screed.
- 4) For one-man-screeding, a powered vibrating screed can be used. Caution: slump cannot be over 3 inches when using this method or surface irregularities will result.

- 5) If slab is under 6 feet wide, one person can use a 1- x 4-inch magnesium screed or a wooden 1- x 4-inch straightedge with a 1/2- x 2-inch shoe strip attached to the bottom.
7. After screeding the surface should be "floated" to straighten out irregularities caused by the screeding. Several types of floats are available.

How is the surface "floated"?

- 1) Wood bull floats, usually used from the side, are pushed away from the operator with the leading edge up and pulled back flat.
 - 2) They measure 2 to 30 inches long by 6 inches wide and are pushed by long broomlike handles.
 - 3) Magnesium floats are lighter and easy to use.
 - 4) Darbies are wood or metal handheld floaters.
 - 5) Knee boards are needed to finish the center of the slab. A 1- x 12-inch board, 24 to 30 inches long, will distribute the finisher's weight.
 - 6) Do not overwork the surface. It should be smooth and even with the top of the forms.
8. "Bleed water" can be a severe problem for the slab finish. Too much water in a mixture can weaken the final finish. For the period that "bleed water" is present leave the surface alone.

What is "bleed water" and its problems?

- 1) Bleeding is caused by the heavier materials in the mix settling.
 - 2) Surface looks wet, watery and may have bubbles.
 - 3) Using air-entrained concrete will reduce bleeding.
 - 4) High slump with no air will bleed excessively.
 - 5) Do not work the surface if "bleed water" is present; the surface cement water ratio is too high and the finish would be weak.
 - 6) Weak surfaces may reduce durability and cause scaling.
 - 7) Delay final finish until "bleed water" is gone and concrete has stiffened.
 - 8) A person's footprint should only sink 1/4-inch when it is ready.
 - 9) Drying time will vary with wind and temperature.
9. How is cracking in the slab controlled? What factors cause the cracks?

Why and how are control joints cut?

- 1) Concrete will expand and contract with changes in moisture and temperature.
- 2) As concrete dries it will shrink,
- 3) If the shrink tensile stress exceeds the tensile strength of the concrete, cracks occur.
- 4) To control cracking cut control joints $1/4$ the thickness of the slab.
- 5) The joint will be a weak point where cracks may occur but below the surface where it is not visible.
- 6) Joint spacing

<u>Slab Type</u>	<u>Recommended Spacing</u>
4 inches thick	10 feet or less
6 inches thick	15 feet or less
Feedlots, walks	width based on slab thickness
Patio's	10 feet or less in either direction
- 7) Joints should make squares in concrete..
- 8) Methods
 - a) Piece of angle iron on a small slab pushed into surface.
 - b) Mason's trowel is used to open a groove. Use a knee board to prevent digging into the surface. Then finish with a groover.
 - c) Mechanical concrete cutter after concrete is firm - 4 to 12 hours.

10. To get a surface that will fit the use, the final finishing will vary with need. Rough or very smooth finishes are available. What type finish would go on a feeding floor? Driveway? Sidewalk? Patio?

How is the surface final finished?

- 1) Cut the concrete away from the forms with a mason's trowel.
- 2) Use an edger to smooth the edges, butt against the forms.
- 3) Float the surface again to remove any irregularities; it compacts the surface
- 4) If possible use a magnesium float; can apply more pressure with less surface tearing
- 5) A power unit with rotating blades can be used.
- 6) Steel troweling is done from knee boards using a hand float for support and a steel trowel that is slightly curved up on the edges to smooth the surface.
- 7) Run the blade as flat as possible.
- 8) Do not trowel too much; it may weaken the surface.
- 9) Successive trowelings should be done with smaller trowels each time so more pressure can be applied.

- 10) Never final finish a livestock or walkway too many times because the dense surface is slippery when wet.
- 11) Final finishing on walkways and feeding areas can be roughed with a broom.
- 12) Pull broom over surface scoring as much as you want.
- 13) Always broom in the direction of the slope to promote drainage.

F. Summary

Finishing the surface is important and should be done carefully to develop a proper surface: rough or smooth, crackfree, and strong. Follow recommendations carefully!

G. Evaluation

Answers to the Exam

1. Study Question 1
2. F
3. Study Question 3
4. Oil and curing compound
5. Study Question 8
6. Study Question 9
7. Study Question 10

UNIT - WORKING WITH CONCRETE

Lesson 4 - How is the concrete slab finished to a proper surface?

EXAM

1. How is a slump test performed? List steps.
 - a.
 - b.
 - c.
 - d.
 - e.
2. The pocket-sized air indicator is more accurate than the pressure method. Circle correct answer. T F
3. What are the proportions of an exterior slab mix per cubic yard?
 - a. Water
 - b. Cement
 - c. Slump
 - d. Entrained air
4. What two methods were named to prevent the concrete from bonding to the forms?
 - a.
 - b.
5. What is "bleed water"?
6. What does a control joint do?
7. How would you final finish a floor for a feedlot?

UNIT - WORKING WITH CONCRETE

Lesson 5 - Why and how are concrete slabs cured?

Objective: By the conclusion of the lesson, the student will be able to explain the hardening cycle of cement, explain curing, list methods available for use, and discuss the affect of weather on the properties of concrete.

Study Questions:

1. How does concrete harden?
2. What methods are available to prevent moisture loss?
3. How does the weather affect the quality of the concrete?

References:

1. Concrete and Concrete Masonry, Hobar Publications, available through Instructional Materials Laboratory, University of Missouri-Columbia, Columbia, Missouri 65211. \$4.95 single \$4.00 over 10.
2. Slide-Tape Set, Concrete Placing, Finishing and Curing Flat Slabs, Instructional Materials Laboratory, University of Missouri-Columbia, Columbia, Mo. 65211. \$55. (Slides 77-80)

UNIT - WORKING WITH CONCRETE

Lesson 5 - Why and how are concrete slabs cured?

TEACHING PROCEDURE

A. Review

- B. Motivation - What is curing? Is curing concrete like curing meat? Who has seen concrete covered by plastic? Why is it covered? Will the weather conditions affect the concrete quality or the way the concrete is cured?

C. Assignment

- D. Supervised Study - Bring in samples of curing methods to show the class. Run an experiment using the various methods from the same batch of concrete and see if differences can be found in the concrete.

E. Discussion

1. What is hydration and curing? Explain that "hydra" means "water" and "ation" refers to "reaction." Relate curing to curing meats.

How does concrete harden?

- 1) The hardening process is due to hydration.
- 2) Hydration is the chemical reaction between water and cement.
- 3) Hydration will continue only if water is present and the temperature is favorable.
- 4) If too much water is lost by evaporation, the concrete will lose expected strength.
- 5) Object is to control evaporation and promote hydration.

2. What concrete covers have you seen? Which is most popular? Do some have advantages over others?

What methods are available to prevent moisture loss?

- 1) Burlap - keep wet 7 days to promote cooling effect. Water evaporates quickly in warm, sunny weather.
- 2) Plastic sheeting is good and easily applied. Weight edges with gravel to trap moisture. Use clear plastic in the summer and black plastic when temperatures are low and heat from the sun is needed.
- 3) Liquid, membrane-forming, curing compound is applied directly after finishing; must be applied evenly for a good seal.

- 4) In winter, use a cover that can trap or supply heat to the concrete to promote curing. Heat may need to be provided if temperature falls below 50 degrees. Therefore, provide a cover that will trap the warmth.
3. Can concrete be placed any time, anywhere without worry or weakened sections? No! Why? Where can it?

How does the weather affect the quality of the concrete?

- 1) Never pour concrete on frozen ground.
- 2) Heated concrete can be ordered to keep the temperature above 50 degrees during placing, finishing and curing.
- 3) If average daily temperature is below 40 degrees, cover slab with straw or insulating blankets to maintain 50-degree temperatures.
- 4) Use high, early-strength concrete for shorter curing time.
- 5) Consult your local supplier for local needs and protection.

F. Summary

Do not pour in weather below 50 degrees unless precautions have been taken to keep the temperature of the mix above 50 degrees. Cold concrete curing will reduce strength and improve the possibility of cracking.

G. Evaluation

Answers to the Exam

1. F
2. T
3. F
4. T
5. F

UNIT - WORKING WITH CONCRETE

Lesson 5 - Why and how are concrete slabs cured?

EXAM

- T F 1. Concrete hardens by air circulating in the mixture after placing.
- T F 2. Curing is a process of controlling water loss from the slab after placing.
- T F 3. Black plastic curing will speed the hardening of concrete in the summer.
- T F 4. The temperature of concrete must stay above 50 degrees during the curing process.
- T F 5. Concrete cannot by any means be placed outside in the winter and cure properly.

UNIT - WORKING WITH CONCRETE

Lesson 6 - How do you estimate the quantity of materials needed to complete a concrete job?

Objective: Upon the conclusion of the lesson, students will be able to calculate the yield of mixes, to make mix corrections, and to prepare an estimate of concrete needed for a given job.

Study Questions:

1. What is the "rule of thumb" method for calculating yield?
2. What is the absolute volume method for calculating yields?
3. What mix corrections are needed in a standard mix?
4. What are the formulas for estimating a concrete job needs?

Reference:

1. Concrete and Concrete Masonry, by Hobar Publications, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211. \$4.95 single, \$4.00 over 10.

UNIT - WORKING WITH CONCRETE

Lesson 6 - How do you estimate the quantity of materials needed to complete a concrete job?

TEACHING PROCEDURE

- A. Review the mixture components of a quality mix of concrete.
- B. Motivation - What might happen if you have to wait several hours or days because you did not order enough concrete? Will the quality drop? What happens if the mix gets too wet?
- C. Assignment - Complete the problems on assignment sheet after completion of discussion and sample problems.
- D. Supervised Study - Do the assignment sheet in class as small groups. Reward the fastest and most accurate group. Set up each group as a construction crew making bids on a job.

E. Discussion

1. Throughout this lesson a 1:2:3 6-gallon mix will be used: 1 cubic foot of cement, 2 cubic feet of sand, 3 cubic feet of gravel and .8 cubic feet of water (6 gallons ÷ 7.5 gallons/cubic feet). This gives us 6.8 cubic feet of concrete.

What is the "rule of thumb" method for calculating yields?

- 1) The "rule of thumb" is the yield will generally be 60 percent of total volume.

Example:

1:2:3 6-gallon mix
 $1 + 2 + 3 + .8$ cu.ft. of water = 6.8 cu.ft.
 $6.8 \times 60\% = 4.08$ cu.ft. concrete

- 2) To calculate the weight of one cubic foot of wet mix, use the following procedure.

Example:

Cement: 1 cu.ft. $\times$ 94 lbs./cu.ft. = 94.0 lbs.
Sand: 2 cu.ft. $\times$ 100 lbs./cu.ft. = 200.0 lbs.

Gravel: 2 cu.ft. x 100 lbs./cu.ft. = 300.0 lbs.
 Water: 6 gal. x 8.3 lbs./gal. = 49.8 lbs.
643.8 lbs.
 $643.8 \text{ lbs.} \div 4.08 \text{ cu.ft.} = 158 \text{ lbs/cu.ft.}$

- 3) Calculate needed materials for a sidewalk 120 feet long, 3 feet wide, and 4 inches thick.
 - a) Cubic feet of concrete needed
 $120 \text{ ft.} \times 3 \text{ ft.} \times 1/3 \text{ ft.} = 120 \text{ cu.ft.}$
 - b) By rule of thumb
 $120 \text{ cu.ft.} \div 4.08 \text{ cu.ft./batch} = 29.41 \text{ batches}$
 - c) Bags of cement needed
 $29.41 \text{ batches} = 29.41 \text{ bags or } 30 \text{ bags cement}$
 - d) Sand and gravel needed
 Sand: $29.41 \text{ batches} \times 2 \text{ cu.ft./batch} = 58.82 \text{ cu.ft.}$
 Gravel: $29.41 \text{ batches} \times 3 \text{ cu.ft./batch} = 88.23 \text{ cu.ft.}$
 - e) Cubic yards of ordered ready mix
 $120 \text{ cu.ft.} \div \text{cu.ft./yd.} = 4.44 \text{ in.yds.}$
- 4) Order 5% over estimate to allow for overrun.

2. Another method is available to calculate cubic feet of concrete. What is it?

What is the absolute-volume method for calculating yields?

- 1) Calculate the percent of solids. Percent of solids times mix ratio equals yield.
 Cement: $.47 \times 1 = .47$
 Sand: $.60 \times 2 = 1.20$
 Gravel: $.55 \times 3 = 1.65$
 Water: $1.00 \times .8 = .80$
 Concrete per batch 4.12 cu.ft.
- 2) Calculate mix as in study question 1.
- 3) Then, allow 5% for overrun.
3. At times corrections need to be made for moisture found in the mixing sand. This moisture will affect the volume and the water content of the mix.

What mix corrections are needed in a standard mix?

- 1) For example, the sand is 5% moisture and has bulked twenty percent by volume.
- 2) Sand correction
 - a) Weight:
 Dry Sand: 200 lbs.
 Wet Sand: $200 \text{ lbs.} \times 5\% \text{ moisture} = 10 \text{ lbs. water}$
 $200 \text{ lbs. sand} + 10 \text{ lbs. water} = 210 \text{ lbs.}$
 - b) Volume:
 Dry Sand: 2 cubic feet
 Wet Sand: $2 \text{ cu.ft.} \times 20\% \text{ bulk} = .4 \text{ cu.ft.}$
 $2 \text{ cu.ft.} + .4 \text{ cu.ft.} = 2.4 \text{ cu.ft.}$

3) Water correction

a) Weight:

6 gallons water in mix x 8.3 lbs./gal. =
49.8 lbs. water
49.8 lbs. water - 10 lbs. water in sand =
39.8 lbs. water

b) Volume:

49.8 lbs. water in mix ÷ 8.3 lbs./gal. =
6 gallons
10 lbs. water in sand ÷ 8.3 lbs./gal. =
1.2 gallons
6 gal. mix - 1.2 gal. in sand = 4.8 gallons

4) Original mix: 1:2:3 6 gallons

a) Corrected volume: 1:2.4:3 4.8 gallons

b) Corrected mix by weight: 94 lbs.:210 lbs.:300 lbs. 39.8 lbs.

5) If the corrections were not made, the results would be:

a) Noncorrected volume: 1:1.66:3 7.2 gallons

b) Noncorrected weight: 94 lbs.:166 lbs.: 300 lbs.;
59.8 lbs.

6) The resulting product would yield less cubic feet of concrete, would have less strength, and would increase the cost of the job.

4. The official unit of measurement for concrete is cubic yard. This is especially important when ordering ready mix concrete.

What are the formulas for estimating concrete job needs?

- 1) A cubic yard is equal to 27 cubic feet.
- 2) Cubic feet = Width (feet) x Length (feet) x Thickness (inches) ÷ 12
- 3) Cubic yards = Cubic feet ÷ 27
- 4) Cubic yards = Width (feet) x Length (feet) x Thickness (feet) ÷ 27
- 5) Cubic yards = Width (feet) x Length (feet) x Thickness (inches) ÷ 324

Example: How much concrete would be required for a 4-inch floor in a 40 x 72 building?

$$\text{cubic feet} = \frac{40\text{ft.} \times 72\text{ ft.} \times 4\text{ in.}}{12} = 960$$

$$\text{cubic yards} = \frac{960}{27} = 35.55$$

7) Again add 5% for overrun.

F. Summary

Work the assignment sheet.

G. Evaluation

Have the students complete the assignment sheet. Collect and grade the assignment sheet or grade it in class in groups.

Assignment Sheet

UNIT - WORKING WITH CONCRETE

Lesson 6 - How do you estimate the quantity of materials needed to complete a concrete job?

Directions: Using the information provided, and the formulas from the lesson complete the problems. Use the "rule of thumb" method when calculating yields.

Information Provided:

Mix is a 2:5:5 12-gallon mix.
Yield is 60% of total volume.

1. Find cubic feet of concrete.

Information Provided:

Cement: 94 lbs./cu.ft.
Sand: 100 lbs./cu.ft.
Gravel: 100 lbs./cu.ft.
Water: 8.3 lbs./gallon

2. Calculate pounds/cubic foot.

Information Provided:

Put in a feeding floor 100 feet by 100 feet by 4 inches thick

3. Calculate cubic yards needed.

4. Calculate cubic feet of sand and gravel needed.

5. Calculate bags of cement needed.

Information Provided:

Sand has 7% moisture and has bulked 25% volume.

6. Calculate sand correction.

7. Calculate water correction.

8. Correct the original mix of 2:5:5 12 gallons.

Information Provided:

Building measures 60 feet by 80 feet with a 4 inch thick floor
9. Calculate the cubic yards needed.

Answer Sheet

UNIT - WORKING WITH CONCRETE

Lesson 6 - How do you estimate the quantity of materials needed to complete a concrete job?

1. $2 + 5 + 5 + (12 + 7.5 \text{ gal./cu.ft.}) = 13.6 \text{ cu.ft.}$
 $13.6 \times 60\% = 8.16 \text{ cu.ft. concrete per batch}$
2. $2 \times 94 = 188 \text{ lbs.}$
 $5 \times 100 = 500 \text{ lbs.}$
 $5 \times 100 = 500 \text{ lbs.}$
 $12 \times 8.3 = 99.6 \text{ lbs.}$
 $\quad \quad \quad 1287.6 \text{ lbs.}$
 $1287.6 + 8.16 \text{ cu.ft. batch} = 157.79 \text{ lbs./cu.ft.}$
3. $100 \times 100 \times .33 \text{ ft.} = 3300 \text{ cu.ft.} + 27 \text{ cu.ft./yd.} = 122.22 \text{ cu.yds.}$
4. First calculate batches needed $3300 \div 8.16 \text{ cu.ft. batch} = 404.41 \text{ batches}$
 Sand $404.41 \times 5 \text{ cu.ft./batch} = 2022.05 \text{ cu.ft.}$
 Gravel $404.41 \times 5 = 2022.05 \text{ cu.ft.}$
5. $404.41 \text{ batches} \div 2 = 202.21 \text{ bags of cement or 203 bags}$
6. Sand correction - $500 \text{ lbs. dry} \times 7\% \text{ moisture} = 35 \text{ lbs. water}$
 $500 + 35 = 535 \text{ lbs.}$
 Volume - $5 \text{ cu.ft.} \times 25\% \text{ bulk} = 1.25 \text{ cu.ft.}$
 $5 + 1.25 = 6.25 \text{ cu.ft.}$
7. $12 \text{ gal. in mix} \times 8.3 \text{ lbs./gal.} = 99.6 \text{ lbs.}$
 $99.6 - 35 \text{ lbs. from sand} = 64.6 \text{ lbs. water}$
 Volume - $99.6 \text{ lbs.} \div 8.3 \text{ lbs./gal.} = 12 \text{ gal.}$
 $35 \text{ lbs. water sand} \div 8.3 = 4.22 \text{ gal.}$
 $12 - 4.22 = 7.78 \text{ gallons}$
8. Corrected volume 2:6.25:5:7.78 gallons
 Corrected by weight 94:535:500 64.4 lbs.
9. $\frac{60' \times 80' \times 4"}{324} = 59.26 \text{ cu.yds.}$
 OR
 $\frac{60 \times 80 \times 4}{12} = 1600 \text{ cu.ft.} \quad \quad \frac{1600}{27} = 59.26 \text{ cu.yds.}$
 OR
 $\frac{60 \times 80 \times .33 \text{ ft.}}{27} = 59.26 \text{ cu.yds.}$

UNIT - WORKING WITH CONCRETE

Lesson 7 - What concrete forms are constructed on the farm?

Objective: Upon the conclusion of the lesson, students will be able to: (1) identify materials used in concrete forms; (2) build forms for walls, slabs, and curves; and (3) properly remove the forms after curing the concrete.

Study Questions:

1. What materials are used for concrete forms?
2. How are wall forms constructed?
3. How are slab forms constructed?
4. What is the proper method of form removal?

Reference:

1. Concrete and Concrete Masonry, by Hobar Publications, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 \$4.95 single, \$4.00 over 10.

Transparency:

1. TM #1: Wall Forms

UNIT - WORKING WITH CONCRETE

Lesson 7 - What forming methods are performed on the farm?

TEACHING PROCEDURE

- A. Review the strengths of various types of wood; and, if time permits, run stress tests on the wood types equal to the pressure applied by the concrete.
- B. Motivation - Have the students form a small wall; pour a lime-sand mixture; and let the mixture set. Then check the wall for plumb and surface quality. Let the class test the strength of the sheeting with and without traces to see the need for wiring tall forms together and bracing all forms.
- C. Assignment
- D. Supervised study - Have the students design a form for a wall using drafting equipment. Check for accuracy; then build and test the best walls.
- E. Discussion
 1. The function of the form is to hold the concrete in place until it hardens. Forms must be carefully planned and then built of quality materials in order to resist the great pressure of the weight of the concrete.

What materials are used for concrete forms?

- 1) Fasteners
 - a) Bolts
 - b) Screws
 - c) Double-headed nails
- 2) Wood, metal, or special manufactured products can be used for side material.
- 3) Lumber needs to be free of knots and decay.
- 4) Use 2-inch by 4-inch boards for 4-inch slabs.
- 5) Use 2-inch by 6-inch boards for 5- or 6-inch slabs.
- 6) Be sure to stake from the outside.
- 7) If plywood is used, specify "Plyform" which is specifically designed for concrete forms.
- 8) Coat surfaces of wood forms with oil to prevent sticking and water absorption.
- 9) If concrete is to be painted or plastered, use a paraffin coating--not oil.

- 10) Metal forms are initially more expensive but can be reused more often than wood.
 - 11) Fiber boards work well on curves because of their flexibility.
 - 12) Earth can be used as a form, but it is discouraged because it may mix with the concrete. Use a plastic or tar lining between the earth and form.
2. Walls are constructed on farms for many reasons. List them on the board. Get suggestions from the class. What are braces?

How are wall forms constructed?

- 1) Each type of form has its own bracing problems.
 - 2) Braces are generally used to support the side boards of the form to keep them from bulging.
 - 3) The side boards can be panelized to facilitate form removal and reutilization.
See TM #1.
 - 4) Straight wall forms need vertical support from braces and No. 10 wire ties to prevent bulging.
See TM #1.
 - 5) Spacer blocks are used to keep forms even but are removed as the concrete is placed.
 - 6) Check for tightness and strength of forms before pouring concrete.
 - 7) Solid metal ties can be used as spacers and ties in the forms.
 - 8) Solidly brace the base and tops of the forms to prevent bulging or bursting.
3. If slabs are to be placed, follow the procedure laid out in the filmstrip series on concrete in the procedure taught and in the earlier lesson.

How are slab forms constructed?

- 1) Set stakes at 4-foot intervals or less.
 - 2) Have a good compacted granular fill.
 - 3) Use quality lumber for side forms.
4. Times may come when the farmer will need to make a curve for a walkway or driveway. Care must be taken to carefully lay out the corner to get a good appearance.

How are curves formed?

- 1) The best material to use is one-fourth inch plywood.
- 2) Secure plywood solidly to the stake at the start of the curve and at the end of the curve. Use one solid piece if possible.

- 3) Set the arc of the curve using a string and set backing stakes at one- to two-foot intervals.
 - 4) Be sure plywood grain is vertical or cracking may occur.
 - 5) For long curves, use heavier lumber and stake at two- to three-foot intervals.
5. After the concrete has hardened, the forms need to be carefully removed. If done properly, there will be a smooth finish on the concrete and the form can be reused.

What is the proper method of form removal?

- 1) Remove form when the concrete can support its own weight and has been adequately cured.
- 2) Remove forms two days after placing in the summer and four to seven days after placing on cool days.
- 3) Be sure to loosen all ties before removing the forms.
- 4) Forms should remove easily if they have been properly coated. If they do not remove easily, check the oiling procedure.

F. Summary

In order to get concrete to hold to a desirable shape, it must be held in that shape for several hours. The use of forms is essential and can be used to stand concrete on end or to confine it to a specific area. The forms must be strong and well constructed to counteract the weight force of the wet concrete mixtures.

G. Evaluation

Answers to the Exam

1. a. Bolts
b. Screws
c. Nails
2. "Plyform"
3. F
4. T
5. F
6. T

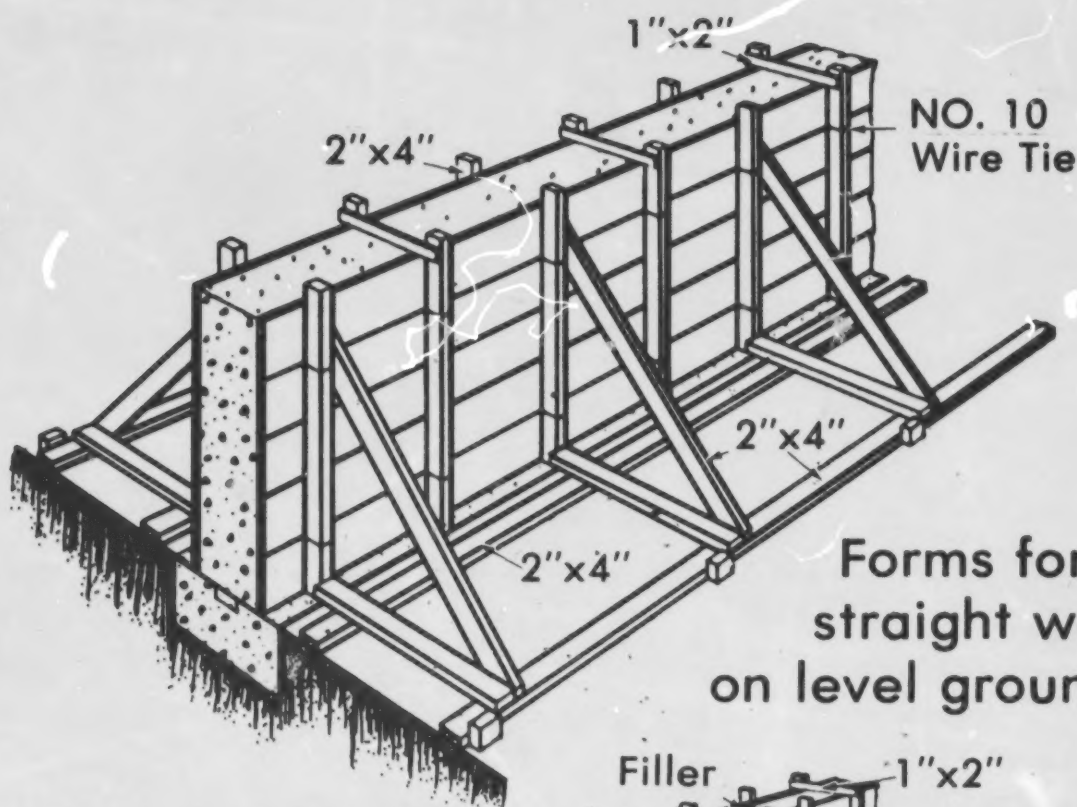
UNIT - WORKING WITH CONCRETE

Lesson 7 - What forming methods are performed on the farm?

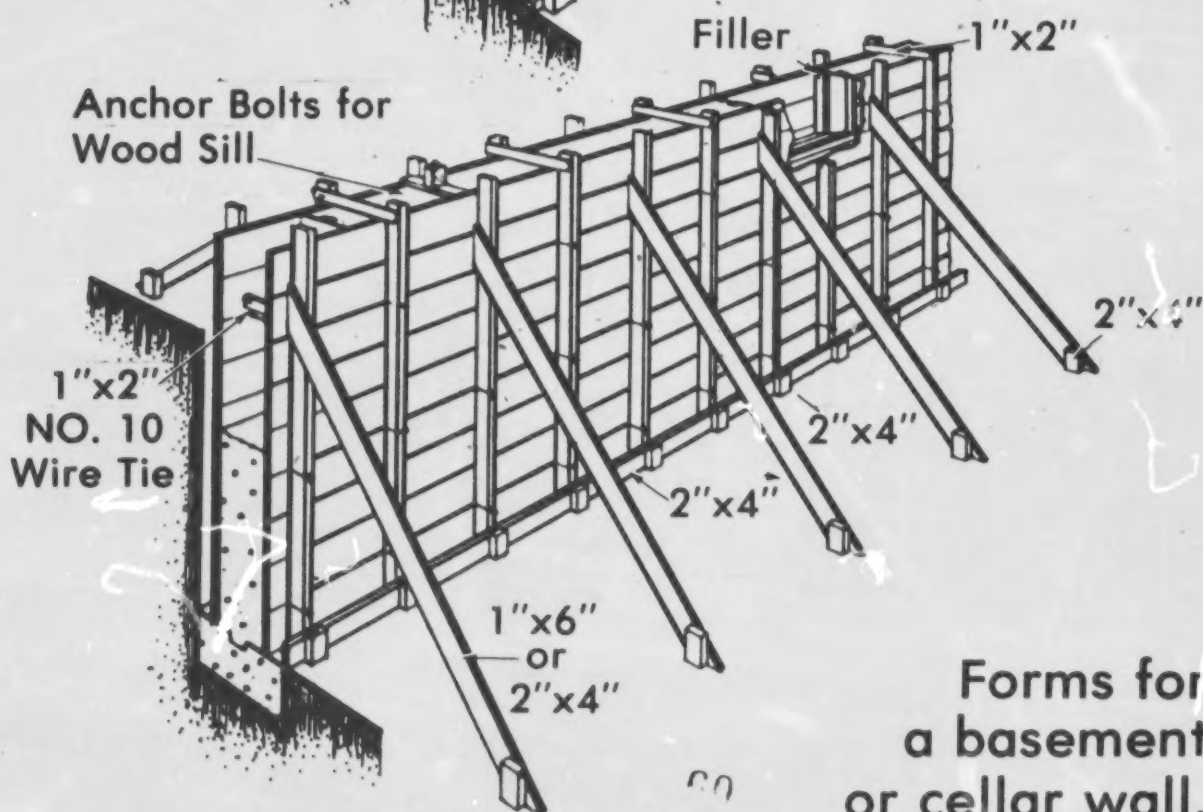
EXAM

1. List three fasteners used to construct forms.
 - a.
 - b.
 - c.
2. What type of plywood is used in concrete forms?
- T F 3. Forms for walls only need bracing at the bottom because that is where the weight of the concrete is concentrated.
- T F 4. Having a good fill base is a necessity for a quality concrete slab.
- T F 5. Curves need staking only on the ends of the board because the weight is concentrated at those points.
- T F 6. Forms can usually be removed in the summer within two days after placing concrete.

Wall Forms



Forms for a straight wall on level ground.



Forms for a basement or cellar wall.

UNIT - WORKING WITH CONCRETE

Lesson 8 - What are the reasons and methods for placing and reinforcing concrete?

Objective: Upon the conclusion of the lesson, students will be able to list rules for placing concrete, explain the need for and methods of vibrating concrete, and discuss the methods and materials involved in reinforcing concrete.

Study Questions:

1. What are the rules for placing concrete?
2. Why should one vibrate concrete?
3. What are the advantages of vibrating concrete?
4. What methods are available for vibrating concrete?
5. Why should one reinforce concrete?
6. Which reinforcing methods are most common?

Reference:

1. Concrete and Concrete Masonry, by Hobar Publications, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211. \$4.95 single, \$4.00 over 10.

Handout:

1. HO #1: Reinforcing Table

UNIT - WORKING WITH CONCRETE

Lesson 8 - What are the reasons and methods for placing and reinforcing concrete?

TEACHING PROCEDURE

A. Review

- B. Motivation - How long does it take for concrete to cure? Does it make any difference how the concrete is placed in the forms? Should reinforcing be used in all types of concrete construction?

C. Assignment

- D. Supervised Study - Mix a small batch of concrete and pour three small bars: (1) Straight pour; (2) Pour and vibrate; and (3) Pour and reinforcing. Test for strength with a hydraulic press.

E. Discussion

1. Concrete, once mixed, is a quick curing composition. How fast does it cure? Does it matter how it is placed in the molds or forms?

What are the rules for placing concrete?

- 1) Place concrete in forms within 30 to 60 minutes after mixing because curing begins in 30 minutes.
- 2) Once curing begins it cannot be remixed or rewetted.
- 3) Place concrete as near as possible to its final position.
- 4) If possible, discharge concrete directly onto the subgrade.
- 5) Aggregate segregation is the biggest problem. The causes of this include:
 - a) Long hauls
 - b) Excessive tamping, spading or vibrating
 - c) Dumping concrete all in one spot and allowing it to run and spread.
- 6) Limit layer depths to six to twelve inches.
- 7) Be sure first layer is consolidated before placing next layer.
- 8) Pour walls at the ends first; then progress to the center.
- 9) If additional layers are to be added to an existing layer, be sure to rough the surface of the first layer before placing the second layer.
- 10) When layering where waterproofing is needed (such as basement wall) apply a water-cement paste before placing the second layer.

2. What does vibration do to concrete? Do all mixes have to be vibrated in order to be strong?

Why should one vibrate concrete?

- 1) The goal of good vibration is compaction.
- 2) Vibration of concrete allows the placement of less workable mixtures than can be placed by hand.
- 3) Vibration causes concrete particles to slide together and settle into place.
- 4) Do not use vibration on hand workable mixes because vibration may cause the separation of aggregates and water.
- 5) Vibration will decrease the air content of concrete.

3. If vibration reduces the air holding capacity (freeze protection), why use it?

What are the advantages of vibrating concrete?

- 1) Increased compressive and flexural strength
- 2) Increased watertightness
- 3) Increased resistance to weathering
- 4) Lower absorption
- 5) Less volume change
- 6) Better bond between successive layers of concrete
- 7) Better bond between concrete and reinforcement
- 8) Earlier form removal
- 9) Earlier finishing of the surface
- 10) Less bulging of the formed walls

4. Are vibrators large? small? portable?

What methods are available for vibrating concrete?

- 1) Three general types of vibrators
 - a) Internal
 - b) Form
 - c) Surface
- 2) Vibrations for most types of vibrating equipment range from 3,600 to 13,000 vibrations per minute.
- 3) Internal vibrators are preferred because they can be placed directly into the concrete.
 - a) Start placing concrete at bottom of slope.
 - b) On successive layers, only penetrate the previous layer a few inches at systematic, regular intervals for good consolidation.
- 4) Form vibrators take considerable energy to start and can damage the forms.
- 5) Form units are used primarily for concrete blocks, lintels, and other cast-in-form products.

- 6) Surface vibrators are used to finish flat work, i.e., pavement, driveways.
5. A property of concrete is its high compressive strength. Its major drawback is its tensile strength. How can we add tensile strength to concrete? Refer to HO #1.

Why should one reinforce concrete?

- 1) Reinforcing adds tensile strength to concrete.
 - 2) Normally compression verses tensile strength is at a ratio of 10 to 1.
 - 3) Steel reinforcing can also be used to give concrete reinforcement to prevent cracking due to changes in temperature.
6. What forms of reinforcement are used in concrete? Are only rods used? When do you use the different kinds of reinforcement?

Which reinforcing methods are most common?

- 1) Most common methods of reinforcement are steel rods and welded wire mesh.
- 2) Be sure all reinforcing is clean and free of rust.
- 3) Rods are usually deformed by adding ribs or lugs to improve mechanical holding ability.
- 4) Rod sizes varying from one-eighth inch to two inches in diameter, are ordered as number 2, 3, 4, 5, or 6, etc. Sizes are in eighths of an inch.
- 5) Welded wire is sold by:
 - a) Gage 0000 to 16 gage
 - b) Spacing 2, 3, 4, 6, 8, 10, 12 and 16 inch spacing
 - c) Rolls come in 36, 42, 48, and 60 inch widths.
 - d) Lengths: 150, 200, 300 feet
- 6) For a 4-inch slab .08 to .12 square inches per square foot is needed
- 7) Guideline: reinforcing rod is not to exceed 5 percent by volume of the amount of concrete.
- 8) Place reinforcement where tension forces are going to be the greatest.
- 9) In a beam this means putting the reinforcing in the lower half where tension is greatest.
- 10) Protect the reinforcement with sufficient concrete.

F. Summary

Vibration is used to consolidate concrete, but excessive vibration may reduce air content and thus weathering ability. When working with a less workable concrete mix, it is important to place quickly. Reinforcing depends on the job, thickness, and points of stress. Some concrete does not need reinforcing, but most concrete over 4 inches thick will benefit from the strength provided slabs and walls.

G. Evaluation

Answers to the Exam

1. T
2. F
3. Any three of the following:
 - a. Long hauls
 - b. Excessive tamping
 - c. Dropping concrete from a height
 - d. Dumping all in one spot
 - e. Vibrating
4. b
5.
 - a. Internal
 - b. Form
 - c. Surface
6. a
7.
 - a. Rod
 - b. Mesh-wire fabric

UNIT - WORKING WITH CONCRETE

Lesson 8 - What are the reasons and methods for placing and reinforcing concrete?

EXAM

- T F 1. Concrete will begin to cure in 30 to 60 minutes after mixing.
- T F 2. Concrete can be rewetted to make it more workable after it has begun to cure.
3. List three causes of aggregate segregation:
- a.
 - b.
 - c.
- _____ 4. Vibration will _____ the air holding capacity of concrete.
- a. Increase
 - b. Decrease
 - c. Not effect
5. List the three types of concrete vibrators.
- a.
 - b.
 - c.
- _____ 6. Concrete is high in _____ strength and low in _____ strength.
- a. Compression, tensile
 - b. Tensile , compression
7. Name the two common types of steel reinforcing.
- a.
 - b.

REINFORCING TABLE

Part A. Size, area, and weight of reinforcing bars.

Bar number	Bar diameter, in.	Bar area, Sq. in.	Approximate weight of 100 ft.
2	1/4	0.05	17
3	3/8	0.11	38
4	1/2	0.20	67
5	5/8	0.31	104
6	3/4	0.44	150
7	7/8	0.60	204
8	1	0.79	267

Part B. Steel area and weight of three sizes of welded wire fabric.

Fabric style	longitudinal steel area, sq. in. per ft.	Transverse steel area, sq. in. per ft.	Weight, lb. per 100 sq. ft.
6 x 6 No. 6	0.058	0.058	42
6 x 6 No. 8	0.041	0.041	30
6 x 6 No. 10	0.029	0.029	21

Part C. Minimum amount of steel for use in reinforced concrete.

Concrete thickness, in.	Minimum amount of steel in each direction, sq. in. per sq. ft. of concrete area
4	0.08 to 0.12
6	0.12 to 0.18
8	0.16 to 0.24
12	0.24 to 0.36

UNIT - WORKING WITH CONCRETE

Lesson 9 - What are the causes of concrete surface defects and how are they prevented from occurring?

Objective: Upon the conclusion of the lesson, students will be able to name the three main concrete surface defects, their causes, and preventive procedures.

Study Questions:

1. What is scaling?
2. What are the causes of scaling and how can the problem be prevented?
3. What is crazing?
4. What are the causes of crazing and how can the problem be prevented?
5. What is dusting?
6. What are the causes of dusting and how can the problem be prevented?

Reference:

1. Cement Mason's Manual for Residential Construction, Portland Cement Association, Old Orchard Road, Skokie, Illinois 60076.

Transparencies:

1. TM #1: Scaling Causes and Preventions
2. TM #2: Crazing Causes and Preventions
3. TM #3: Dusting Causes and Preventions

UNIT - WORKING WITH CONCRETE

Lesson 9 - What are the causes of concrete surface defects and how are they prevented from occurring?

TEACHING PROCEDURE

- A. Review the steps in final finishing, darbying, floating, and troweling.
- B. Motivation - How many of you have ever seen a deteriorated surface on a concrete pad or sidewalk? Do you know what causes the problem?
- C. Assignment
- D. Supervised Study - In class try to duplicate the problems to be discussed in the body of this lesson. The use of heat lamps, fans, and salts will duplicate the problems or locate them around the school grounds for the problems.

E. Discussion

1. Scaling is the most obvious of the methods, because it is common to most flat surfaces. Find examples in your area for the class to see. See TM #1.

What is scaling?

- 1) Scaling is when the surface of hardened concrete slab breaks away from the slab to the depth of 1/16- to 3/16 inch.
- 2) Scaling occurs at an early age of the slab.
2. Scaling occurs for several reasons which must be controlled when placing the concrete. The four main causes are listed.

What are the causes of scaling and how can the problem be prevented?

- 1) Cause: Freezing and thawing of newly placed concrete.
Prevention: Maintain temperature above 50°F for 5 days.
- 2) Cause: Freezing and thawing of non-air-entrained concrete.
Prevention: Use air-entrained concrete.
- 3) Cause: Application of deicing salts on non-air-entrained concrete.
Prevention: Use air-entrained concrete.

- 4) Cause: Faulty workmanship. Finishing steps performed when concrete is "bleeding water".
Prevention: No finishing steps when free water is present. Evaporate the water.
3. Crazeing is another common problem with slab concrete which weakens the surface. Again, look for examples around the school. See TM #2.

What is crazeing?

- 1) Crazeing is the occurrence of numerous fine hair cracks in the surface of a newly hardened slab due to surface shrinkage.
- 2) These cracks form an overall pattern similar to a crushed eggshell.
4. There are three main causes of crazeing in concrete. This is another common defect which can be easily controlled if preventive steps are taken.

What are the causes of crazeing and how can the problem be prevented?

- 1) Cause: Rapid surface drying by sun and/or wind.
Prevention: Apply fog spray or cover with burlap canvas. Keep damp after screeding and darbying.
- 2) Cause: Premature floating and troweling on a moist surface coupled with rapid loss of moisture.
Prevention: Be sure surface is free of moisture before working. Reduce slump and use air-entrained concrete.
- 3) Cause: Over use of jitterbug, vibrating screed, darby or bull float. Works too much mortar to surface.
Prevention: Use tools sparingly. Excess mortar at surface tends to cause surface shrinkage.
5. Look for a dusty surface on some concrete in the area. Ask for possible causes from the class. See TM #3.

What is dusting?

- 1) Dusting is the appearance of a powdery material at the surface of a newly hardened concrete slab.
6. The powdery surface has six causes to be mentioned here. The above mentioned problems are often found in conjunction with this problem.

What are the causes of dusting and how can the problem be prevented?

- 1) Cause: Excess of clay or silt in concrete. They mix with sand and cement at surface.
Prevention: Use clean and well-graded coarse and fine aggregate.
- 2) Cause: Premature floating and troweling.
Prevention: Delay floating and troweling until after initial set.
- 3) Cause: Addition of carbon dioxide from cold weather heating systems into the surface which impairs proper hydration.
Prevention: Vent heat fumes to the outside. Provide sufficient ventilation.
- 4) Cause: Condensation in the surface before floating and troweling operations have been completed. Occurs in spring and fall when materials get cold with no provision for heating at night.
Prevention: Heat the concrete, use hot water in mixing, use blower-type heaters to lower humidity. If condensation occurs, use a mixture of one part Portland cement and one part concrete sand, spread evenly and lightly over the surface. Immediately float and trowel.
- 5) Cause: Dry-heat heaters may lower humidity too quickly. Concentration of heat will inhibit proper hydration.
Prevention: Put water jacket on heater to increase humidity. Move heater periodically to move heat concentration.
- 6) Cause: No curing or inadequate curing.
Prevention: Proper curing for the specified length of time is essential.

F. Summary

The three common defects of concrete are scaling, crazing, and dusting. Proper placement, finishing, and curing is essential to prevent these problems.

G. Evaluation

Answers to the Exam

1. b
2. a
3. c
4. a. Heat concrete and maintain 50°F
b. Use air-entrained concrete
5. c

UNIT - WORKING WITH CONCRETE

Lesson 9 - What are the causes of concrete surface defects and how are they prevented from occurring?

EXAM

Match the definition to the proper term.

- | | |
|---|------------------------------------|
| _____ 1. Scaling | a. Fine-hair cracks in the surface |
| _____ 2. Crazing | b. Breaking of the surface |
| _____ 3. Dusting | c. Powdery material on the surface |
| 4. List the two preventions of scaling from the freezing and thawing of concrete. | |
| a. | |
| b. | |
| _____ 5. Clay and silt are a cause of: | |
| a. Scaling | |
| b. Crazing | |
| c. Dusting | |

Scaling Causes and Preventions

Definition: Scaling is when the surface of hardened concrete slab breaks away from the slab to the depth of 1/16 to 3/16-inch. Scaling occurs at an early age of the slab.

CAUSE

PREVENTION

1) Freezing and thawing of newly placed concrete.

Maintain temperature above 50°F for 5 days.

2) Freezing and thawing of non-air-entrained concrete.

Use air-entrained concrete.

3) Application of deicing salts on non-air-entrained concrete.

Use air-entrained concrete.

4) Faulty workmanship. Finishing steps performed when concrete is "bleeding water."

No finishing steps when free water is present. Evaporate the water.

Crazing Causes and Preventions

Definition: Crazing is the occurrence of numerous fine-hair cracks in the surface of a newly hardened slab due to surface shrinkage. These cracks form an overall pattern similar to a crushed eggshell.

CAUSE

- 1) Rapid surface drying by sun and/or wind.
- 2) Premature floating and troweling on a moist surface coupled with rapid loss of moisture.
- 3) Over use of jitterbug, vibrating screed, darby or bull float. Works too much mortar to surface.

PREVENTION

- Apply fog spray or cover with burlap canvas. Keep damp after screeding and darbying.
- Be sure surface is free of moisture before working. Reduce slump and use air-entrained concrete.
- Use tools sparingly. Excess mortar at surface tends to cause surface shrinkage.

Dusting Causes and Preventions

TM-3

Definition: Dusting is the appearance of a powdery material at the surface of a newly hardened concrete slab.

CAUSE

PREVENTION

1) Excess of clay or silt in concrete. They mix sand and cement at surface.

Use clean and well-graded coarse and fine aggregate.

2) Premature floating and troweling.

Delay floating and troweling until after initial set.

3) Addition of carbon dioxide from cold weather heating systems into the surface which impairs proper hydration.

Vent heat fumes to the outside. Provide sufficient ventilation.

4) Condensation in the surface before floating and troweling operations have been completed. Occurs in spring and fall when materials get cold with no provision for heating at night.

Heat the concrete, use hot water in mixing, use blower type heaters to lower humidity. If condensation occurs, use a mixture of one part Portland cement and one part concrete sand, spread evenly and lightly over the surface. Immediately float and trowel.

5) Dry-heat heaters may lower humidity too quickly. Concentration of heat will inhibit proper hydration.

Put water jacket on heater to increase humidity. Move heater periodically to move heat concentration.

6) No curing or inadequate curing.

Proper curing for the specified length of time is essential.

UNIT - WORKING WITH CONCRETE

Lesson 10 - What methods are available to produce slip-resistant concrete floors?

Objective: Upon the conclusion of the lesson, students will be able to list the ways to roughen new floors and to roughen hardened floors.

Study Questions:

1. What are slip-resistant concrete floors?
2. What methods are used to roughen new floors?
3. What methods are used to roughen hardened floors?

References:

1. Slip Resistant Concrete Floors, AED-19, by Midwest Plan Service, available through Agricultural Extension Service, University of Missouri-Columbia, Columbia, MO 65211.

Transparencies:

1. TM #1: New Floor Roughening
2. TM #2: Hardened Floor Roughening

UNIT - WORKING WITH CONCRETE

Lesson 10 - What methods are available to produce slip-resistant concrete floors?

TEACHING PROCEDURE

- A. Review
- B. Motivation - Who has ever slipped on a wet or manure covered feeding floor? What methods are available to roughen floors?
- C. Assignment
- D. Supervised Study - Build a steel or wood groover in class. Pour a small pad and show the effects of grooving the concrete.
- E. Discussion
 1. A slick concrete floor can be very dangerous to livestock and people. Rub your hand across the different types of rougheners and roughening patterns.

What are slip-resistant concrete floors?

- 1)
 - 1) Troweling causes a glazed surface which is slick when wet.
 - 2) Broom finishing will wear quickly from scraping and animal traffic.
 - 3) Degree of roughness depends on use of concrete slab.
 - 4) Deep grooves are harder to clean and are rough on small animals.
 - 5) Needed for traction and stability.
2. To roughen a new floor is much easier than trying to work on an old one. The new floors can be easily scored but care must be taken to be sure the concrete is hard enough to hold the marks. See TM #1.

What methods are used to roughen new floors?

- 1)
 - 1) Rough surfaces are made when surface is wet but firm.
 - a) Expanded metal roller
 - b) Wood grooves
 - c) Steel grooves
- 2) Gritty surfaces can be developed by applying aluminum oxide grit at a rate of 1/4-to 1/2-pound per square foot, coarse grit 4 to 6 meshes per inch is recommended.

3. If problems are experienced on an old concrete floor, it can be roughened in several ways. Treat the surface before it becomes so slippery that the animals have difficulty walking. See TM #2.

What methods are used to roughen hardened floors?

- 1) Chemical roughening with muriatic (hydrochloric) acid reacts with the lime and removes the glaze.
 - a) Use extreme care when applying.
 - b) Do not breathe fumes.
 - c) 1 part water:muriatic acid
 - d) 1 gallon acid will treat 200 to 300 sq. feet.
 - e) Concrete will fizz during reaction.
 - f) Flush with water after fizzing stops.
- 2) Use mechanical roughening to cut grooves or chip surface.
 - a) More difficult and time consuming
 - b) Machines can be rented.
 - c) Can roughen with scraper blade, weld beads to blade.
 - d) Use chains on scraper tractor tires.
- 3) Heat causes concrete to flake, slow process.
- 4) Paint may not stick, expensive.
- 5) Pour a new 2-inch layer of concrete.

F. Summary

Having a slip-resistant floor can cut down on injuries to the animals. There are many methods available but it is best to perform the roughening right after installation of the pad.

G. Evaluation

Answers to the Exam

1. a. Mechanical
b. Grit
2. a. Chemical
b. Mechanical
c. Heat
d. Paint or new layer

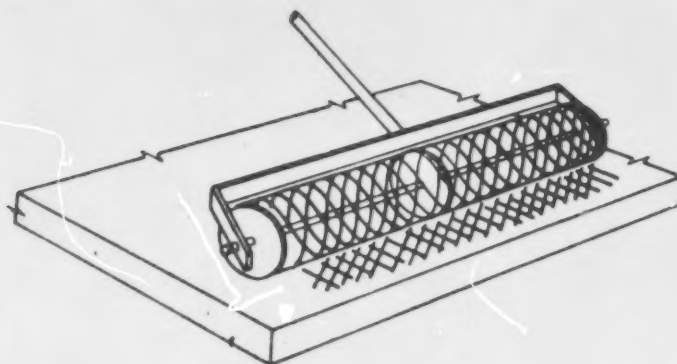
UNIT - WORKING WITH CONCRETE

Lesson 10 - What methods are available to produce slip resistant concrete floors?

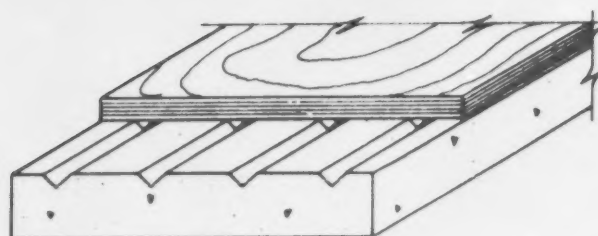
EXAM

1. List the two methods of roughening new floor.
 - a.
 - b.
2. List four methods of roughening hardened floors.
 - a.
 - b.
 - c.
 - d.

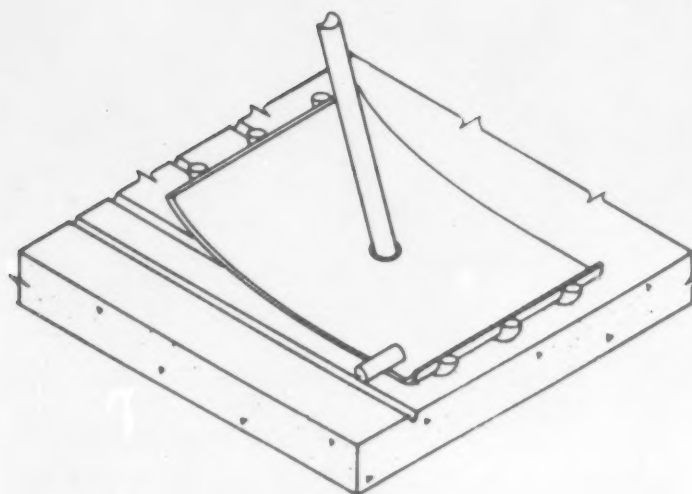
New Floor Roughening



Expanded Metal Roller



Wood Grooves



Steel Grooves

HARDENED FLOOR ROUGHENING

- 1. Chemical**
- 2. Mechanical**
- 3. Heat Treatment**
- 4. Paint**
- 5. Two-inch concrete layer**

UNIT - WORKING WITH CONCRETE

Lesson 11 - What is concrete masonry?

Objective: By the conclusion of the lesson, students will be able to name the uses of concrete masonry and why it is used in the building industry.

Study Questions:

1. How extensively is concrete masonry used?
2. What characteristics of masonry block make it a popular building material?
3. What is meant by concrete masonry and how are blocks made?
4. What are the characteristics of concrete masonry units?

References:

1. Recommended Practices for Building with Concrete Masonry, Agricultural Engineering Department, University of Illinois, Urbana, Illinois 61801.
2. Concrete and Concrete Masonry, Hobar Publications, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Mo. 65211.

Transparency:

1. TM #1: Masonry Construction

UNIT - WORKING WITH CONCRETE

Lesson 11 - What is concrete masonry?

TEACHING PROCEDURE

A. Review

- B. Motivation - Who in the class has ever constructed a course of blocks? What types of buildings are made of block? Demonstrate how to construct a block.

- C. Assignment - Locate in the community the different types of buildings made of block.

D. Supervised Study

E. Discussion

1. Concrete masonry is widely used in the construction of buildings. List on the board examples of concrete masonry found in the community.

How extensively is concrete masonry used?

- 1) More than two-thirds of all masonry walls are built of concrete masonry.
- 2) Types of buildings: Homes, apartments, schools, churches, office buildings, and farm buildings

2. Each building material used in construction has positive characteristics.

What characteristics of masonry block make it a popular building material?

- 1) Beauty in construction
- 2) Fire safety
- 3) Economical
- 4) Durable
- 5) Exhibits good workmanship
- 6) Low maintenance cost

3. What goes into a concrete masonry block? How is the block formed?

What is meant by concrete masonry and how are blocks made?

- 1) Concrete masonry blocks are a combination of Portland cement; fine and coarse aggregate; and water

- 2) Aggregates include:
 - a) Sand
 - b) Gravel
 - c) Crushed stone
 - d) Cinders (cinder block)
 - e) Burned shale
 - f) Processed slag
 - g) Pumice
 - h) Scoria
- 3) Heavyweight or lightweight units can be used.
 - a) Description of heavyweight units: 40 to 60 pounds; 8 by 8 by 16 inches, hollow core; made from sand, gravel, crushed stone
 - b) Description of lightweight units: 25 to 3½ pounds; 8 by 8 by 16 inches, hollow core; made from shale, slag or clay, cinders, or pumice
- 4) Lightweight units are lighter, easier to handle, and have higher insulating value.
- 5) Three methods used to manufacture units
 - a) Tamping into molds
 - b) Consolidated by vibrating
 - c) Consolidated by pressure
 - d) Above methods then cured in a kiln at 125° to 175°F to harden into blocks
- 6) Two grades of blocks
 - a) Grade A: compressive strength of 1000 psi
 - b) Grade B: compressive strength of 700 psi
- 7) Grade A blocks are used for exterior walls below grade or blocks exposed to frost.
- 8) Grade B blocks are used in areas with no frost problems.

4. Are all concrete blocks shaped the same 8 by 8 by 16 inches? What other types are there available? Why have the different sizes and shapes? See TM #1.

What are the characteristics of concrete masonry units?

- 1) Concrete blocks come in 4, 6, 8, 10, and 12 inch widths.
- 2) Blocks come in many shapes. See TM #1.
 - a) Three-core block; two-core block; stretcher block; long-wall block
 - b) Corner block: smooth, corner finish
 - c) Partition block: narrow, interior-wall block
 - d) Jamb block: for setting windows and doors

- e) Bull-nose block: streamlining corners
- f) Header block: windows and doors
- 3) Basic block size: 8 by 8 by 16 inches
becomes $7 \frac{5}{8}$ by $7 \frac{5}{8}$ by $15 \frac{5}{8}$ inches with
a $\frac{3}{8}$ -inch mortar joint addition

F. Summary

Concrete blocks are made of a cement-aggregate mix which is forced into a mold shape by various methods. The blocks are formed into shapes designed for specific purposes but are carefully controlled as to basic block size.

G. Evaluation

Answers to the Exam

1. T
 - a. Houses
 - b. Apartments, schools, churches, offices, farm buildings
2.
 - a. Beauty
 - b. Fire safety
 - c. Economical, durable, low maintenance
3. b
4. Grade A and Grade B
5. Setting doors and windows

UNIT - WORKING WITH CONCRETE

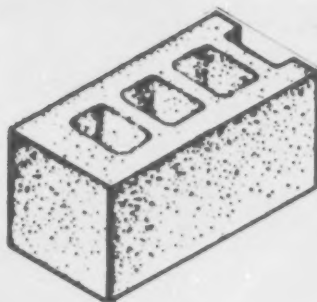
Lesson 11 - What is concrete masonry?

EXAM

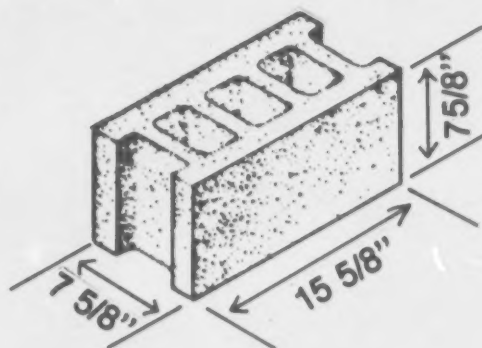
- T F 1. More than two-thirds of all masonry walls are built of concrete masonry. Give two examples.
- a.
 - b.
2. List three reasons for building with concrete masonry.
- a.
 - b.
 - c.
- _____ 3. Blocks made from sand, gravel, or crushed stone are classified as: (Circle the correct answer.)
- a. lightweight
 - b. heavyweight
 - c. middleweight
4. The two grades of block are _____ and _____.
5. Jamb blocks and header blocks are used for what reasons when constructing a building?

Masonry Construction

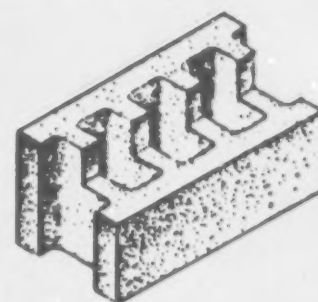
Sizes and Shapes of Concrete Masonry Units



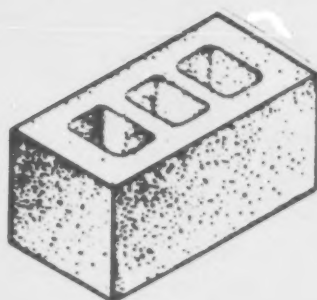
Corner Unit



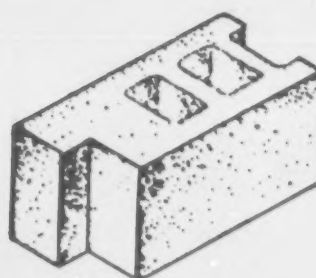
Three Core- 8"x8"x16"
Also 10" & 12" widths



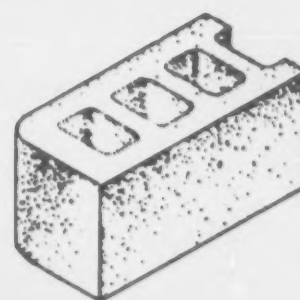
Header Unit



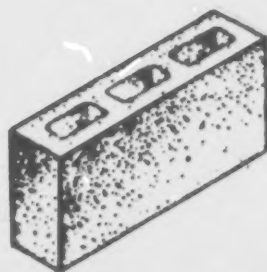
Pier or Double
Corner Unit



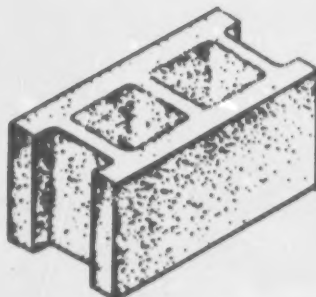
Jamb or Joist Unit
Also Bull Nose



Bull Nose
Corner Unit Also
Double Bull Nose



4"x8"x16"
Partition Unit



Two Core- 8"x8"x16"
Other Spaces as Shown
for Three Core



4"x4"x12" or 16"
Partition Unit

UNIT - WORKING WITH CONCRETE

Lesson 12 - What building layout is needed for a block building foundation?

Objective: By the conclusion of the lesson, the student will be able to lay out the corners of a building without surveying equipment.

Study Questions:

1. How are the base lines established?
2. How do you lay out the corners by the right-angle method?

Reference:

1. Recommended Practices for Building with Concrete Masonry, Agricultural Engineering Department, University of Illinois, Urbana, Illinois 61801.

Transparency:

1. TM #1: Layout

UNIT - WORKING WITH CONCRETE

Lesson 12 - What building layout is needed for a block building foundation?

TEACHING PROCEDURE

- A. Review the size of the blocks.
- B. Motivation - How is a building line established? Who in the class has ever constructed a building foundation?
- C. Assignment
- D. Supervised Study - On a grassy area of the school grounds, lay out a small structure. Measure and check for squareness.
- E. Discussion
 1. The base lines represent one end of the building from which the measurements will be made for the other two corners. See TM #1.

How are the base lines established?

- 1)
 - 1) Establish a base line by marking out one end or side of the new building.
 - 2) Locate two corners by driving two stakes along the line to mark corners A and B. See TM #1.
 - 3) In the top of stake A, drive a nail near the center to accurately locate the corner.
2. The right-angle method will give a fairly accurate lay out of the corners. Be careful not to over correct if the stakes get out of line.

How do you lay out the corners by the right-angle method?

- 1) Drive a stake at F (See TM #1) six feet from stake A on line A-B.
- 2) Drive a nail in the top of stake F; it should be exactly 6 feet from the nail in stake A.
- 3) Drive stake E so its center is exactly eight feet from the center of stake A and exactly 10 feet from the center of stake F.
- 4) This forms a right angle on the corner A-E-F.
- 5) Extend A-E line to form a second boundary. (This would be A-D.)
- 6) Repeat the procedure for each of the corners.

- 7) Set up batter boards at each of the corners about 4 to 6 feet off the corners (See TM #1) and stretch the line to them.
- 8) The lines should cross over each of the corner stakes A-B-C-D to form the four boundaries of the building.

F. Summary

Carefully stretch the lines to limit possible errors. The lines can be removed as can the stakes for excavation, but mark the line points on the batter boards.

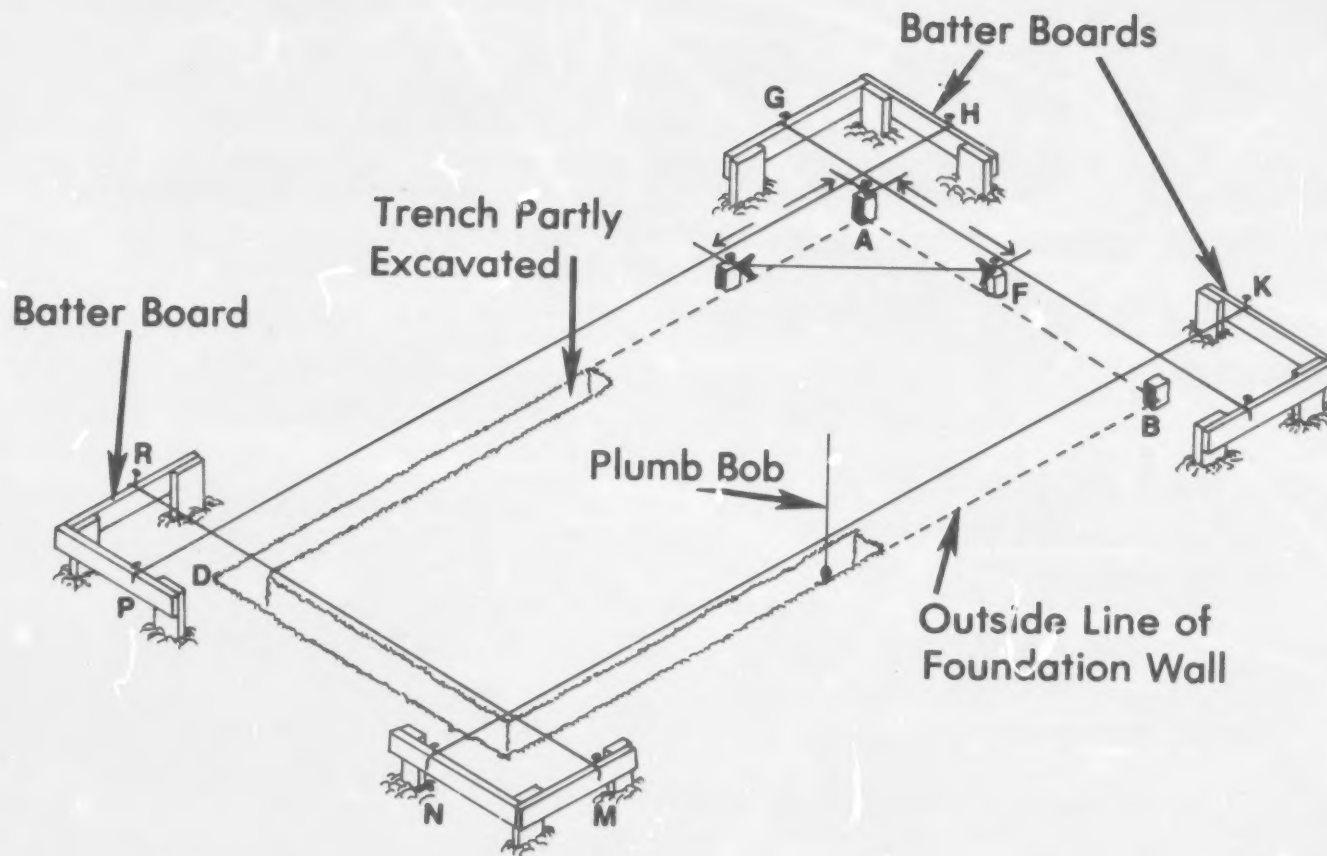
G. Evaluation

Practical Exam

Without the use of survey equipment, lay out a building having dimensions of 20 feet x 40 feet. Check for plumb, distance, and squareness.

Grade according to the instructor's criteria.

Layout



TW-1

UNIT - WORKING WITH CONCRETE

Lesson 13 - How are the footings constructed for block buildings?

Objective: By the conclusion of the lesson, the student will be able to plan, form, and cast a footing for a concrete block building.

Study Questions:

1. What factors need to be considered when selecting the footing locations?
2. What building factors need to be considered when planning the building?
3. How is the size of the footing determined and how are the forms constructed?
4. How is a footing cast for a block-wall building?

References:

1. Recommended Practices for Building with Concrete Masonry, Agricultural Engineering Department, University of Illinois, Urbana, Illinois 61801.
2. Concrete and Concrete Masonry, Hobar Publications, available through Instructional Materials Laboratory, 10 Industrial Education Building, University of Missouri-Columbia, Mo. 65211. \$4.95 singles, \$4.00 over 10.

Transparency:

1. TM #1: Footing

UNIT - WORKING WITH CONCRETE

Lesson 13 - How are the footings constructed for block buildings?

- A. Review the properties of a basic mix concrete.
- B. Motivation - Can a footing be placed anywhere without proper casting or soil analysis? What is the function of the footing?
- C. Assignment - Measure the size of a footing on your home farm and check the footing for stress or cracking.
- D. Supervised Study - Dig and cast a footing corner or construct on a flat surface a set of forms for a footing.
- E. Discussion
 - 1. Footings are used to provide an even surface on which to start the walls. What do you do if the ground is uneven?

What factors need to be considered when selecting the footing locations?

- 1) Good drainage from the site
 - 2) Minimum of foundation excavation needed
 - 3) Need to cut a level foundation bed
 - 4) If freezing is a problem, locate footings below the frost line which is at least three feet below grade.
 - 5) If freezing is not a problem, locate footings two feet below grade.
 - 6) Place footing on undisturbed earth or well-compacted, suitable fill material.
 - 7) In hilly areas
 - a) Construct the footings in steps.
 - b) Avoid sharp corners which can cause cracks.
- 2. Good footings are a necessity for building concrete block structures. How are the dimensions of the footings determined?

What building factors need to be considered when planning the building?

- 1) Determine the nominal length of the wall using full-size blocks.
 - a) Blocks full = 15 5/8 inches long; 3/8-inch joints
 - b, Blocks half = 7 5/8 inches long; 3/8-inch joints

c) Subtract one 3/8-inch joint for each end.

OR

d) Use 11 5/8-inch full blocks and 5 5/8 inch half blocks.

- 2) Plan to use full or half blocks. Limit the need for cutting special blocks.
- 3) Use standard size windows and doors.
 - a) Windows 4' 8" high by 4' wide
 - b) Doors 7' 4" high by 3' 4" wide
 - c) Use precast lintels and sills.
- 4) Determine nominal height of the wall by calculating the number of courses.
 - a) Use 7 5/8 inches high; 3/8-inch joints.

OR

- b) Use 3 5/8 inches high; 3/8-inch joints.
- 5) Check the soil load, carrying capacity (Hobar, pg. 111).
 - a) Clay, soft - 1 ton per square foot
 - b) Hard, dry clay or coarse sand - 4 tons psi
 - c) Gravel - 6 tons psi
- 6) Check weights of building materials (Hobar, pg. 111).
- 7) Check weights of feed (Hobar, pg. 111).

3. An important factor is to determine the size of the footing that is to be placed. Generally, "rules of thumb" are applied; but if your area has unusually gravelly or soft clay soils, consult a local building contractor for suggestions. See TM #1.

How is the size of the footing determined and how are the forms constructed?

- 1) For most buildings the footing should be twice as wide as the thickness of the wall and equal to or half of the wall thickness in depth.
- 2) For an 8-inch wall the footing is 16 inches wide and 8 inches deep.
- 3) The bottom of the footing should be flat and level.
- 4) Excavate the trench so that it slopes away from the form location.
- 5) Construct forms of 2-inch lumber held by stakes outside the forms. See TM #1.

4. In most cases involving the placing of a building footing, a ready mixed will be used as the source of concrete. Be sure the forms are reinforced and clean before placing.

How is a footing cast for a block wall building?

- 1) Clean the forms before placing.
- 2) Use a mixture specifically for footings.
 - a) When using average wet sand, use 5 1/2 gallons of water per sack of concrete.
 - b) 2 3/4 cubic feet of sand
 - c) 4 cubic feet of gravel, less than 1 1/2 inches in size
- 3) In warm weather, forms can be removed in two days.
- 4) In cool weather, forms can be removed in four to seven days.

F. Summary

The footing is the basis upon which the building is built. If the footings fail, the entire building could shift and crack. Take your time when digging and placing the footings.

G. Evaluation

Answers to the Exam

1. F
2. F
3. F
4. four
5. twice, equal to or half

UNIT - WORKING WITH CONCRETE

Lesson 13 - How are the footings constructed for block buildings?

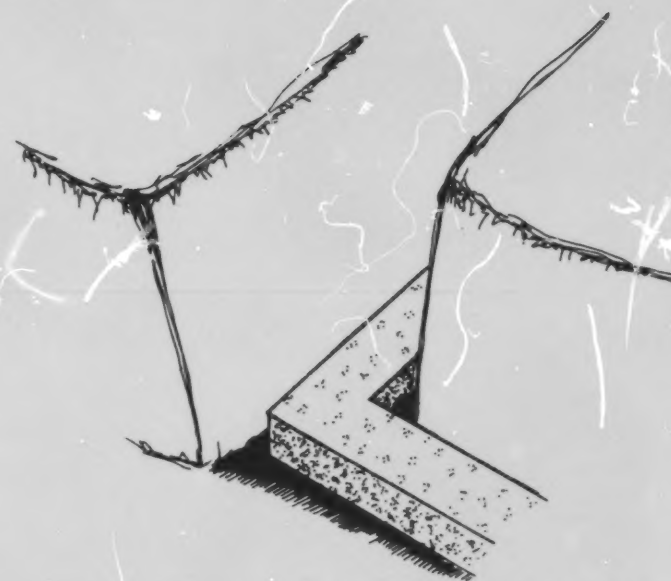
EXAM

- T F 1. If freezing is a problem in your area, the footings should be at least one foot below the surface grade.
- T F 2. A standard block measures 8 by 8 by 16 inches.
- T F 3. A mortar joint measures 5/8-inches.
4. A course of blocks 63 5/8 inches long contains _____ standard blocks.
5. The "rules of thumb" for calculating the size of a footing are to make the footing _____ as wide as the wall thickness and _____ of the wall thickness in depth.

Footing



The height of the footing should be $\frac{1}{2}$ the width.



Remove the forms carefully after the concrete hardens.

UNIT - WORKING WITH CONCRETE

Lesson 14 - How is the mortar mixed for concrete masonry?

Objective: By the conclusion of the lesson, the student will be able to discuss the factors which affect the strength of the mortar and to mix a batch of mortar according to recommendations of use.

Study Questions:

1. What factors affect the strength of mortar?
2. What is the proper mix of mortar? How are the quantities calculated?
3. What are the characteristics of usable mortar?
4. What care is given to the blocks before construction?

References:

1. Recommended Practices for Building with Concrete Masonry, Agricultural Engineering Department, University of Illinois, Urbana, Illinois 61801.
2. Concrete and Concrete Masonry, Hobar Publications, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Mo. 65211.

UNIT - WORKING WITH CONCRETE

Lesson 14 - How is the mortar mixed for concrete masonry?

- A. Review mixing concrete.
- B. Motivation - Why is the quality of the mortar important?
- C. Assignment
- D. Supervised Study - Mix up batches of mortar in class and test the workability and strength of each.
- E. Discussion

1. Good mortar is necessary to good wall performance. The mortar must bond tightly in order to have a strong wall.

What factors affect the strength of mortar?

- 1) The type and quality of materials
- 2) The workability of the mortar
- 3) The surface texture of the mortar bedding areas
- 4) The rate of suction of the blocks
- 5) The water retentivity of the mortar
- 6) The quality of workmanship in laying up blocks

2. Before starting, the total amount of mortar to be used needs to be calculated. In what units are these amounts computed?

What is the proper mix of mortar? How are the quantities calculated?

- 1) Mortar is measured in cubic feet.
- 2) Mixes of 1 sack (part) masonry cement and 3 parts sand yield 3 cubic feet of mortar per sack of cement.
- 3) Mixes of 1 part masonry cement, 1 part Portland cement, and 6 parts sand yield 6.2 cubic feet of mortar per sack of cement.
- 4) For ordinary service-walls, parts are:
 - a) 1 masonry cement; 2 to 3 damp sand
 - b) 1 Portland cement; 1 to 1 1/4 hydrated lime; 4 to 6 damp sand
- 5) For walls subject to extremes such as frost, loads, etc., parts are:

- a) 1 masonry cement plus 1 Portland cement;
4 to 6 damp sand
- b) 1 Portland cement; 0 to 1/4 hydrated lime,
2 to 3 damp sand
- 6) For 8-inch or 12-inch walls per 100 square
feet of wall
 - a) 112.5 blocks
 - b) 3 cubic feet of mortar

OR

- c) 2.65 cubic feet for 100 blocks

- 3. Like concrete the mortar needs to have a good workability before using to achieve maximum strength.

What are the characteristics of usable mortar?

- 1) Mortar will stiffen because of evaporation. Thoroughly mix in additional water if stiffening occurs (called retempering).
- 2) If the mortar has started to cure (hydration) discard mixture.
- 3) Use within 2 1/2 hours of mixing if temperature is 80°F or over, within 3 1/2 hours if air temperature is below 80°F.
- 4) Mortar must be sticky enough to adhere to the blocks and trowel.
- 5) Place mortar near work to minimize movement.
- 4. The building is only as good as the quality of the blocks to be used in the construction. They must receive proper care if a quality job is to be completed.

What care is given to the blocks before construction?

- 1) Keep the blocks dry on the job.
 - a) Elevate off the ground, on boards.
 - b) Cover with a waterproof material.
- 2) Blocks will absorb large amounts of water. (Demonstrate by placing a pint of water on the side of a standard block.)
- 3) Handle carefully to prevent chipping or cracking.

F. Summary

Different mixes are used for different jobs. The main point is to keep the mixture workable and the blocks dry.

G. Evaluation

Answers to the Exam

1. E

2. T

3. F

4. T

5. F

UNIT - WORKING WITH CONCRETE

Lesson 14 - How is the mortar mixed for concrete masonry?

EXAM

- _____ 1. The strength of the mortar is affected by the following factor(s):
- a. Quality of materials
 - b. Surface texture of mortar
 - c. Rate of suction of the blocks
 - d. a and b
 - e. All of the above
- T F 2. Mortar is measured in cubic feet.
- T F 3. A sack (1 part) of masonry cement will make 3 cubic feet of mortar when mixed with 6 parts sand.
- T F 4. Two hundred feet of wall will contain approximately 225 blocks.
- T F 5. Blocks easily shed water so they do not need to be covered.

UNIT - WORKING WITH CONCRETE

Lesson 15 - How is the first course of blocks constructed?

Objective: By the conclusion of the lesson, the student will be able to lay out, mortar, and construct the first course of blocks.

Study Questions:

1. How is the layout of the first course determined?
2. Where is the mortar applied for the best bonding?
3. How are the blocks in the first course checked for correctness?

References:

1. Recommended Practices for Building with Concrete Masonry, Agricultural Engineering Department, University of Illinois, Urbana, Illinois 61801.
2. Concrete and Concrete Masonry, Hobar Publications, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Mo. 65211.

Transparencies:

1. TM #1: Mortar Bed
2. TM #2: Buttering Block
3. TM #3: Side Alignment
4. TM #4: Grade
5. TM #5: Plumb

UNIT - WORKING WITH CONCRETE

Lesson 15 - How is the first course of blocks constructed?

TEACHING PROCEDURE

- A. Review
- B. Motivation - Have the students check the level on the blocks currently in the shop. Check the alignment, plumb, and grade of the block. Show them the mortar joints and how the corners come together.
- C. Assignment - Check the alignment of a block building on the home farm.
- D. Supervised Study - Construct a small corner using a chalk line and six or more blocks using a level to check alignment.

E. Discussion

1. After the footings have been placed and cured, the first course of blocks are added to begin raising the walls. How is the location of the corners determined?

How is the lay out of the first course determined?

- 1) Relocate the exact corners of the structure.
- 2) Use a chalk line drawn between the two corners to set the first course alignment.
- 3) Construct the first course of blocks without mortar to check spacing.
- 4) Be sure to leave a 3/8-inch spacing between blocks to allow for mortar fill.

2. The making of a good mortar bed is very important to the success of the building. This procedure must be done carefully to insure a good footing between the footing and the block.

Where is the mortar applied for the best bonding?

- 1) A full bed of mortar should be spread and furrowed with a trowel to insure that plenty of mortar comes in contact with the blocks on their bottom edges. See TM #1.
- 2) After checking for alignment with the chalk line and level, lay the corner block.
- 3) Lay all blocks with the thicker end of the face shell up.

- 4) Apply mortar (buttering) to the ends of blocks being laid. See TM #2.
 - 5) Each block is brought to its final position and pushed downward into the mortar bed against the previously laid block.
 - 6) After 3 or 4 blocks have been pushed into the mortar bed, check their alignment.
3. The alignment of the blocks is the most important step of the laying procedure. What angles need to be checked? How is it done?

How are the blocks in the first course checked for correctness?

- 1) The mason's level is the best tool to check alignment.
- 2) Check the blocks for proper side alignment. See TM #3. Tap the blocks into the proper alignment with a trowel handle.
- 3) Check the grade by looking at the bubble level in the mason's level. Tap the block down to get the proper level. Check both the inside and outside edges of the block. See TM #4.
- 4) Check the plumb by using the mason's level bubble to check up and down evenness. See TM #5.
- 5) Take extra care on the first course. If the first course is off, it will seriously affect the succeeding courses of block.

F. Summary

The key to a successfully built block building is to have an aligned, graded, and plumbed first course. The first course is the key to a straight, well-built wall.

G. Evaluation

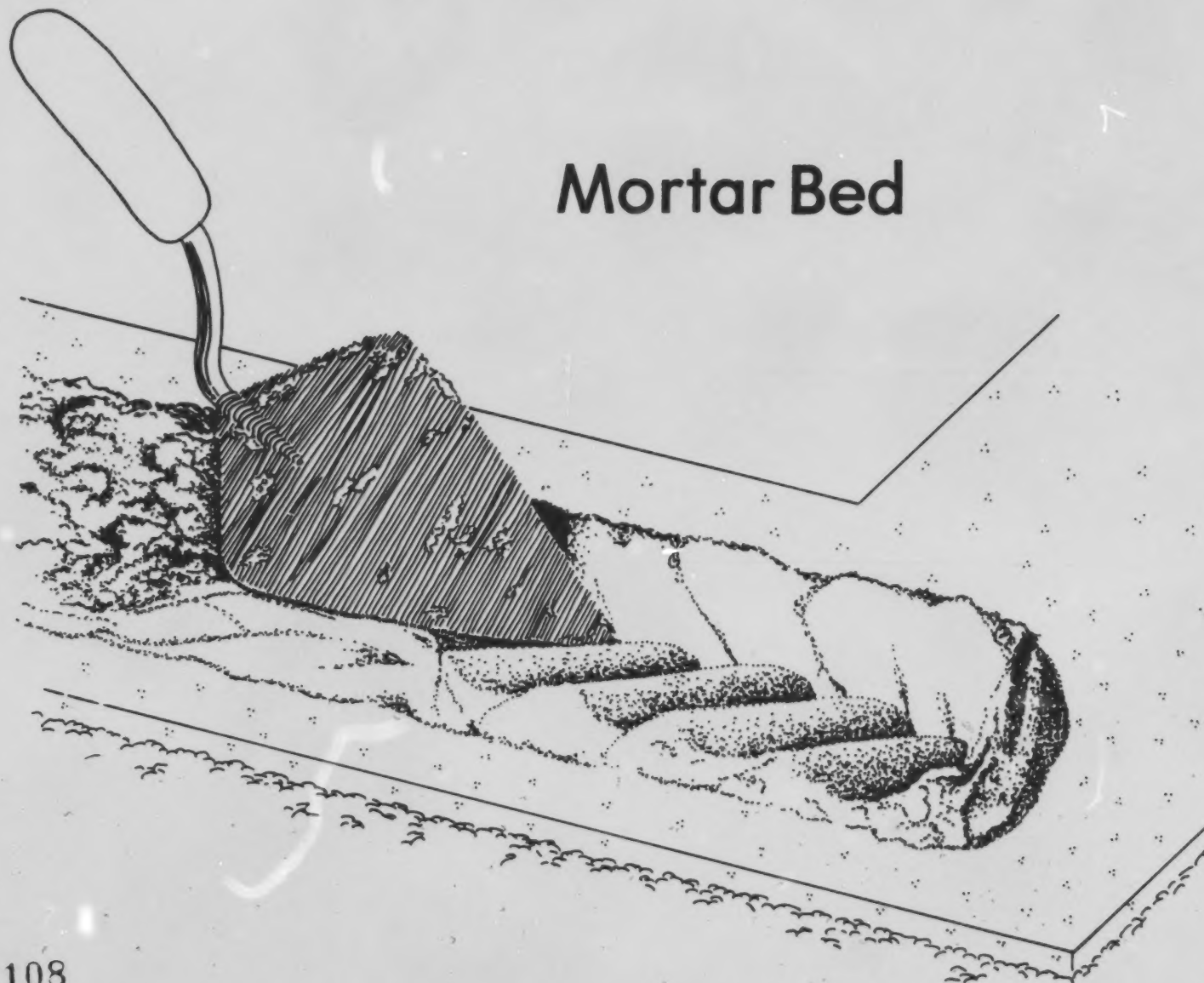
Practical Exam

Using a lime-sand mortar mix have the students perform the following:

1. Mark the courses with a chalk line.
2. Lay four blocks (one being the corner) and align carefully.

Grade the students on alignment, joint size, and use of mortar (too much, too little).

Mortar Bed



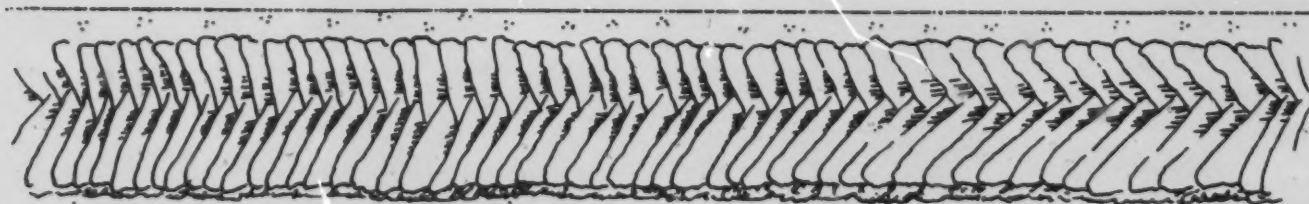
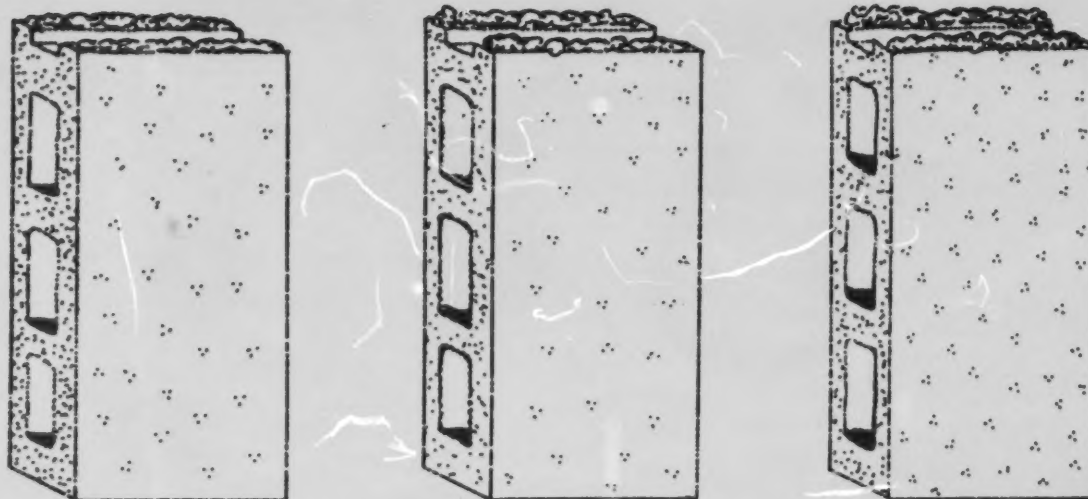
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TM-1

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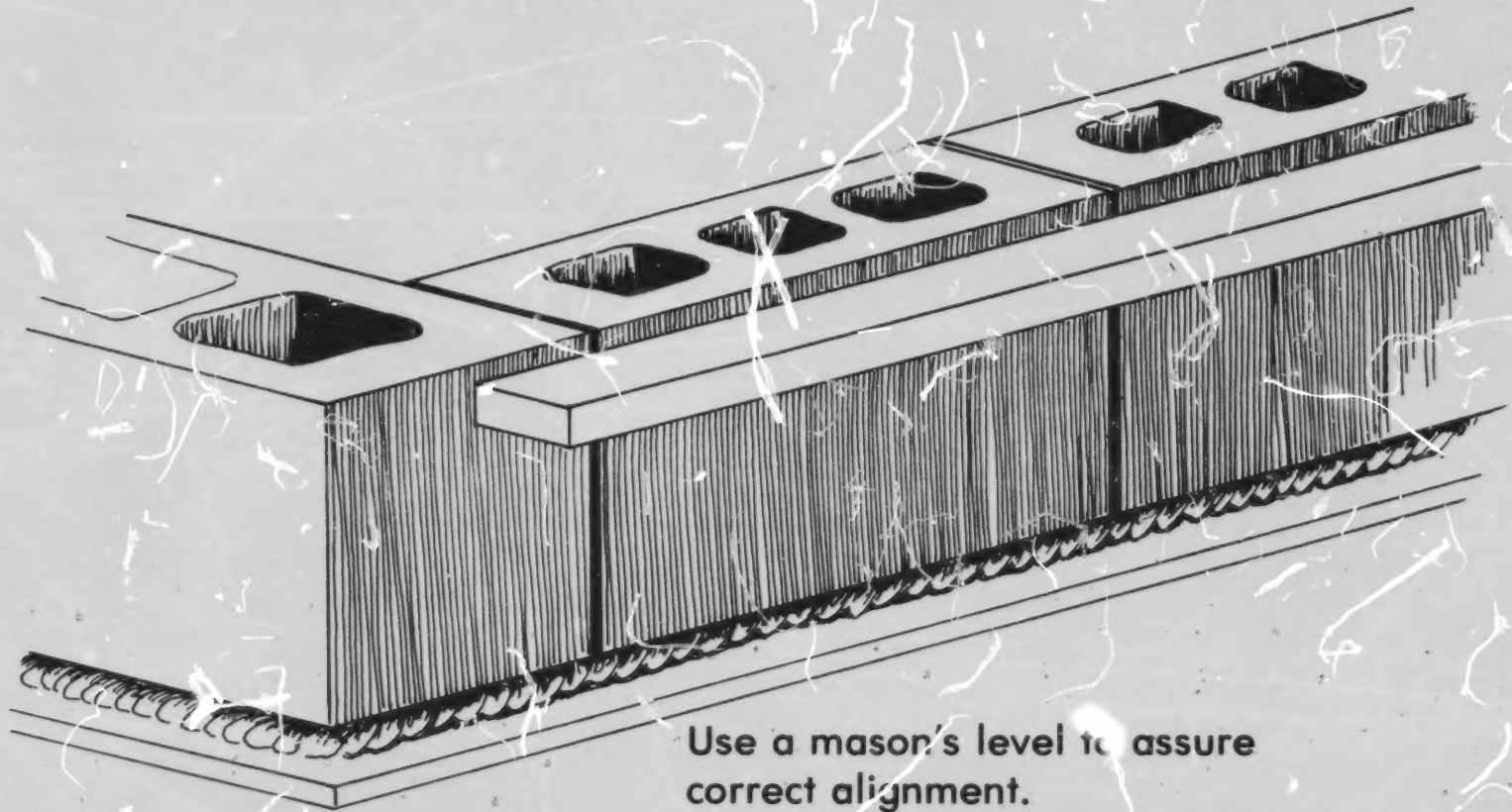
Buttering Block



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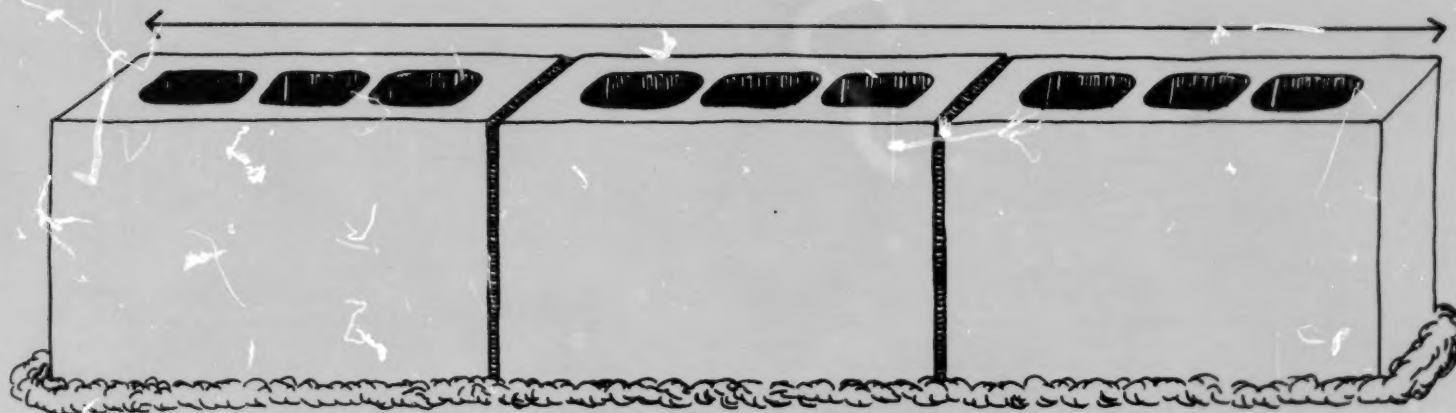
111 TM-2

Side Alignment

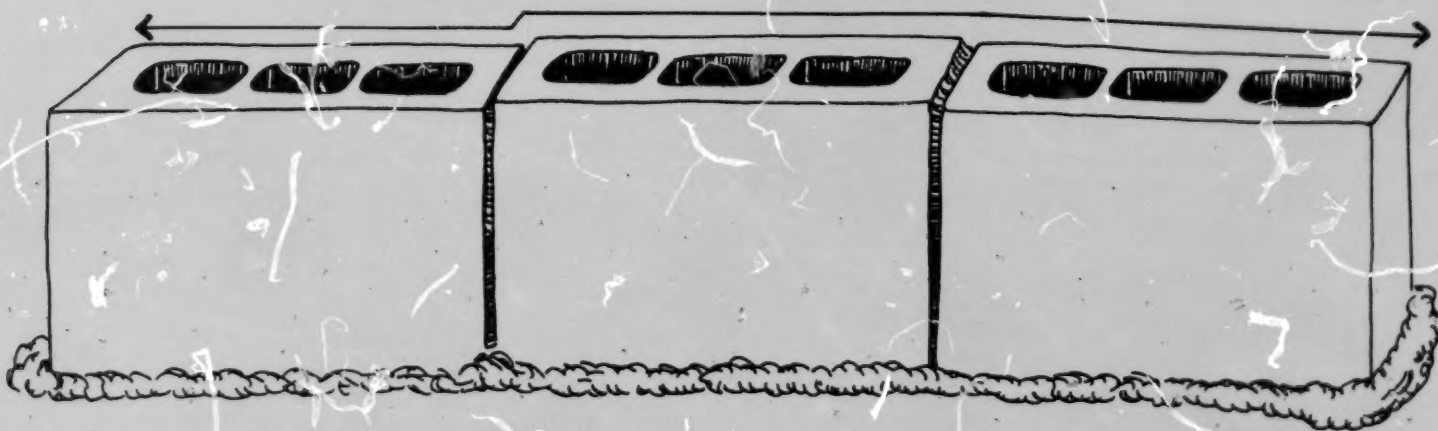


Use a mason's level to assure correct alignment.

Graded

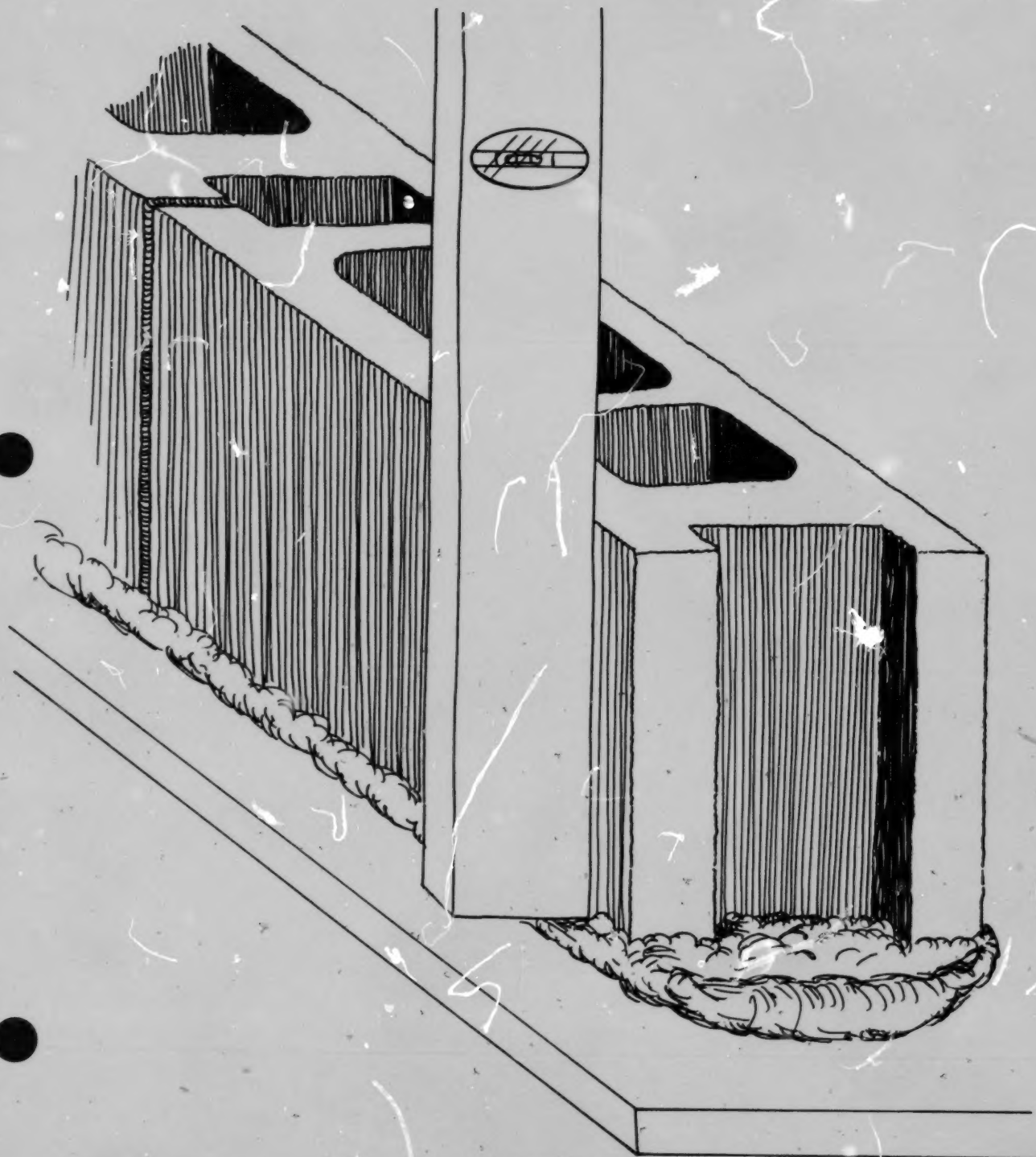


Not Graded



TM-5

Plumb



143116

UNIT - WORKING WITH CONCRETE

Lesson 16 - How are the corners of a block building constructed?

Objective: By the conclusion of the lesson, the student will be able to construct a block corner.

Study Questions:

1. How are the blocks prepared for construction of corners?
2. What squaring techniques need to be performed after each course is constructed?
3. What is a story- or course-pole?
4. How is horizontal spacing checked?

Reference:

1. Recommended Practices for Building with Concrete Masonry, Agricultural Engineering Department, University of Illinois, Urbana, Illinois 61801.

Transparencies:

1. TM #1: Four-Course Corner
2. TM #2: Course-Pole
3. TM #3: Horizontal Spacing

UNIT - WORKING WITH CONCRETE

Lesson 16 - How are the corners of a block building constructed?

TEACHING PROCEDURE

- A. Review the first course, especially buttering a block and preparing a mortar bed.
- B. Motivation - Why are the corners constructed first?
- C. Assignment
- D. Supervised Study - Use the lime-sand mortar to demonstrate construction of corners
- E. Discussion

1. After the first course is constructed and aligned, the next step is to build the corners. This activity builds strength where it is needed which is the point where the walls will end.

How are the blocks prepared for construction of corners?

- 1) Apply mortar to the horizontal-face shells of the block.
- 2) Apply mortar to the vertical-face shells of the block to be placed or to the block already in place.

2. As in the previous lesson the blocks need to be checked for squareness. This is usually done after each new course is constructed.

What squaring techniques need to be performed after each course is constructed?

- 1) Check each course for alignment.
- 2) Check for level at the corner.
- 3) Check for plumb with the rest of the wall.
- 4) Check all block faces to see if they are in the same plane.
- 5) Build the corner usually four or five courses higher than the center of the wall. See TM #1.

3. Even if the wall is aligned, there could be other problems such as improper block spacings either too small. What can be used to check this spacing?

What is a story- or course-pole?

- 1) A pole with markings 8 inches apart
- 2) Provides an accurate method of finding the top of the masonry for each course. See TM #2.

4. When building up the corners on each successive course, the blocks are stepped back a half block. How can the proper spacing of half blocks be checked?

How is horizontal spacing checked?

- 1) Use a level or straightedge.
- 2) Place the level diagonally across the lower corners of the block. See TM #3.
- 3) If spacing is correct, the lower corners should all touch the level or straightedge.

F. Summary

When building, always start by building up the corners first and by checking carefully for squareness.

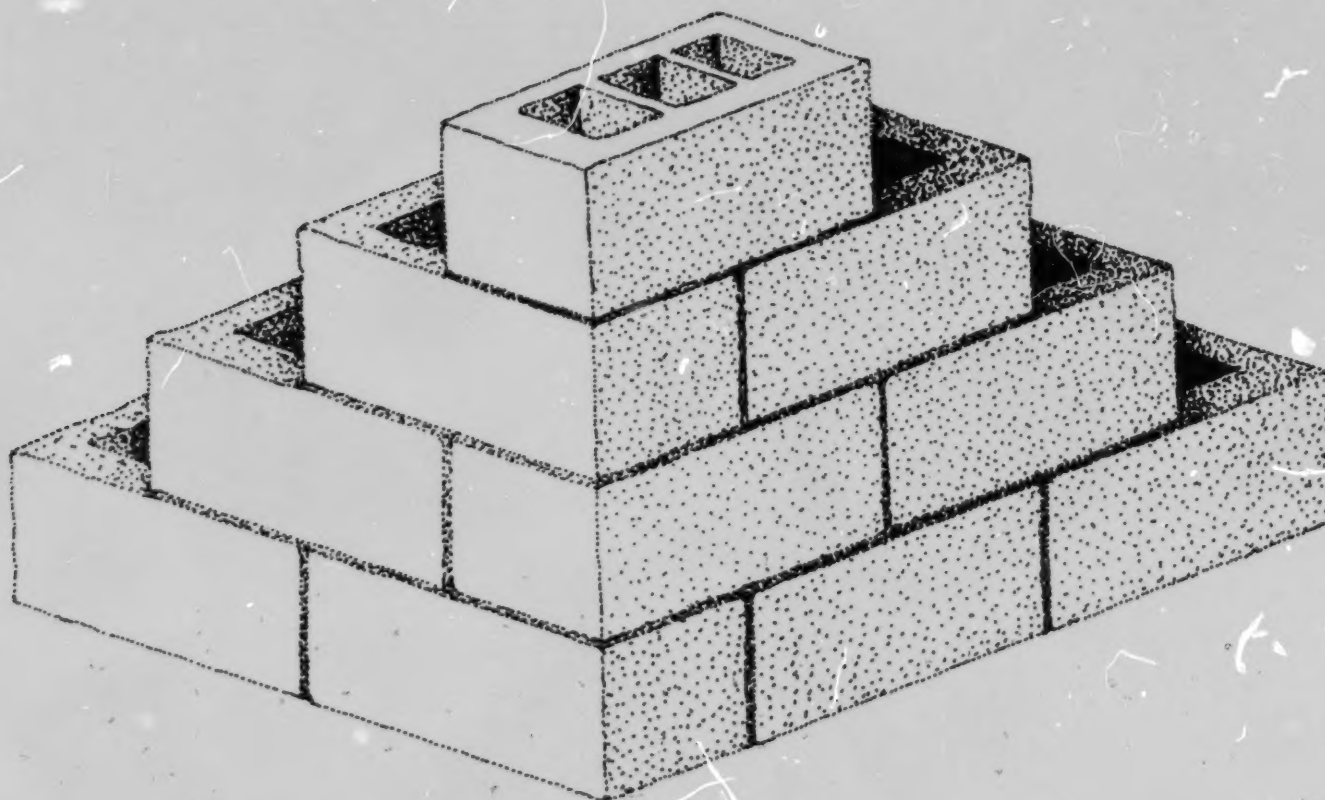
G. Evaluation

Practical Exam

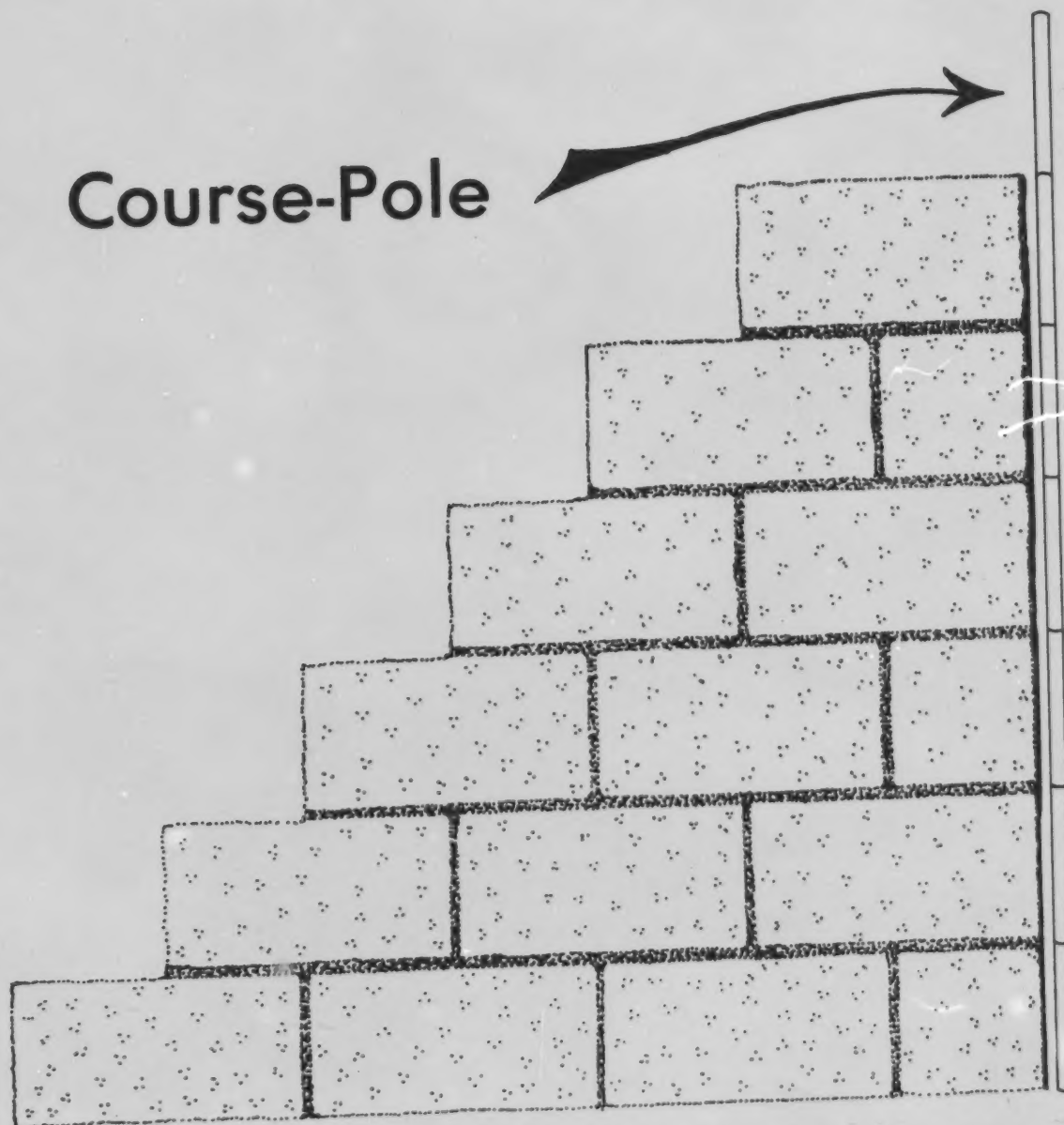
Build a four-course corner on the first course built in the last lesson. Use the lime-sand mortar and check every course carefully for:

- ___ 1. Alignment
- ___ 2. Level
- ___ 3. Plumb
- ___ 4. Block faces square
- ___ 5. Courses 8 inches apart
- ___ 6. Diagonal spacing correct

Four-Course Corner

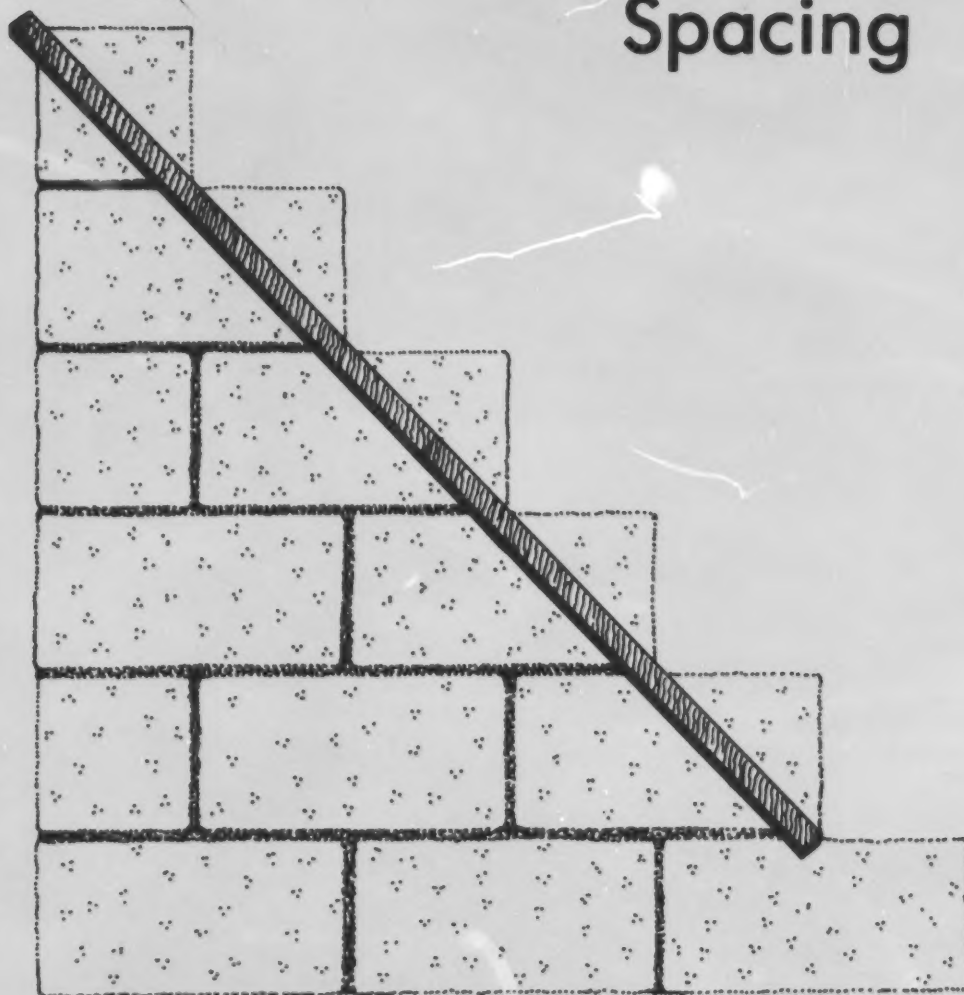


Be sure each course is level at the corner.



A course-pole is used to check the top of each course.

Horizontal Spacing



Use a level on the corners of the block to check horizontal spacing.

UNIT - WORKING WITH CONCRETE

Lesson 17 - How are the blocks laid between corners?

Objective: By the conclusion of the lesson, the student will be able to demonstrate the proper use of the mason's line and how to lay blocks between corners.

Study Questions:

1. How is a mason's line used properly?
2. How are the blocks handled when constructing the wall?
3. Which alignment factors must be considered when constructing wall courses?
4. How is the closure block installed?

References:

1. Recommended Practices for Building with Concrete Masonry, Agricultural Engineering Department, University of Illinois, Urbana, Illinois 61801.
2. Concrete and Concrete Masonry, Hobar Publications, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Mo. 65211.

Transparencies:

1. TM #1: Mason's Line
2. TM #2: Block-Wall Placement
3. TM #3: Closure Block

UNIT - WORKING WITH CONCRETE

Lesson 17 - How are the blocks laid between corners?

TEACHING PROCEDURE

- A. Review the use of the mason's tools for leveling blocks and applying mortar to blocks.
- B. Motivation - Once the corners have been constructed, how are the walls filled in? Find a wall around the school which has blocks that are not in proper alignment. Discuss how to correct and prevent such problems.
- C. Assignment
- D. Supervised Study - Have the class place blocks between the corners which were set in an earlier lesson. Practice using the mason's line on the corners and have the students align block. Check the placements carefully.

E. Discussion

1. Use a mason's line to insure proper placement of each course of block laid between the corners. How is it attached? How accurate is the line? Can anything else be used to perform the same job? See TM #1.

How is a mason's line used properly?

- 1) Stretch the line from corner to corner at the top of the outside corner of each course.
- 2) Lay intermediate blocks with the top outside edge of each block to this line.
- 3) Cord can be fastened by nails or wedges set in mortar joints of each corner.
- 4) Be sure line is taut.
- 5) Top edge of wall blocks should just touch the line.

2. It is very important to handle the blocks in a careful manner to insure a tight wall. Development of a technique which works for each individual is important. Practice handling block before constructing any walls. See TM #2.

How are the blocks handled when constructing the wall?

- 1) Select a style which is easiest for you.

- 2) Tip the block slightly toward yourself to allow for proper placement. This method allows you to see the lower course clearly.
 - 3) Then roll the block slightly to the vertical position.
 - 4) Shove the block against the adjacent block.
 - 5) Once contact with the mortar has been made, do not lift as air may weaken the joints.
3. After initial placement has been made in the wall, the block needs to be checked for alignment. How is this done?

Which alignment factors must be considered when constructing courses?

- 1) Check the alignment of the mason's line.
 - 2) Check plumb level.
 - 3) Tap with trowel to set alignment.
 - 4) When block is set, strike off excess mortar.
4. The last block laid in the wall is called the closure block. How is its placement different from the other blocks? See TM #3.

How is the closure block installed?

- 1) Apply mortar to all edges of the opening and to all four vertical edges of the block.
- 2) Lower the block carefully into the opening.
- 3) If any mortar falls off, remove the block and reapply the mortar.
- 4) Align the block, and then start the next course.

F. Summary

The walls can be constructed quickly once a technique for handling block has been established by the builder.

G. Evaluation

Practical Exam

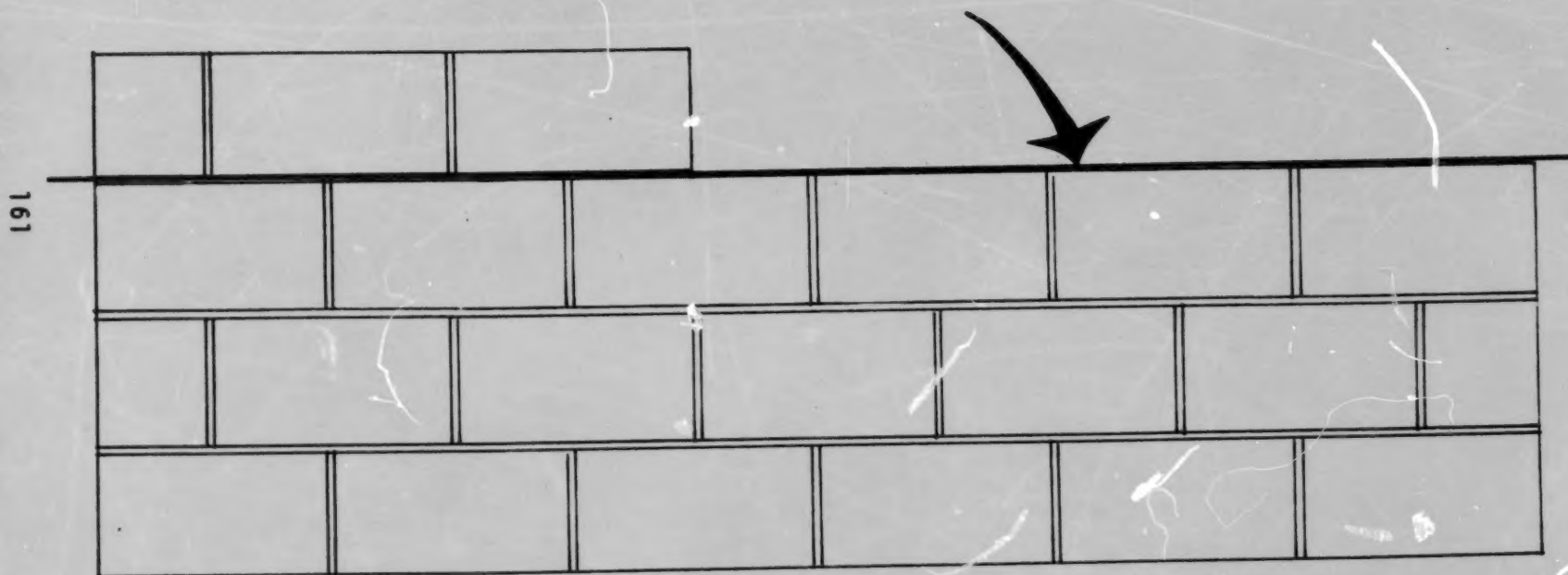
Construct a course of four to five blocks between a set of constructed corners using a lime-sand mortar mixture.

Grade the procedure of each student using the following as a checklist:

- ____ 1. Use of mason's line

- ___ 2. Handling block
- ___ 3. Block alignment
- ___ 4. Speed of placement
- ___ 5. Repetition needed to place a block
- ___ 6. Placement of closure block

Mason's Line



161

128

129

Block-Wall Placement

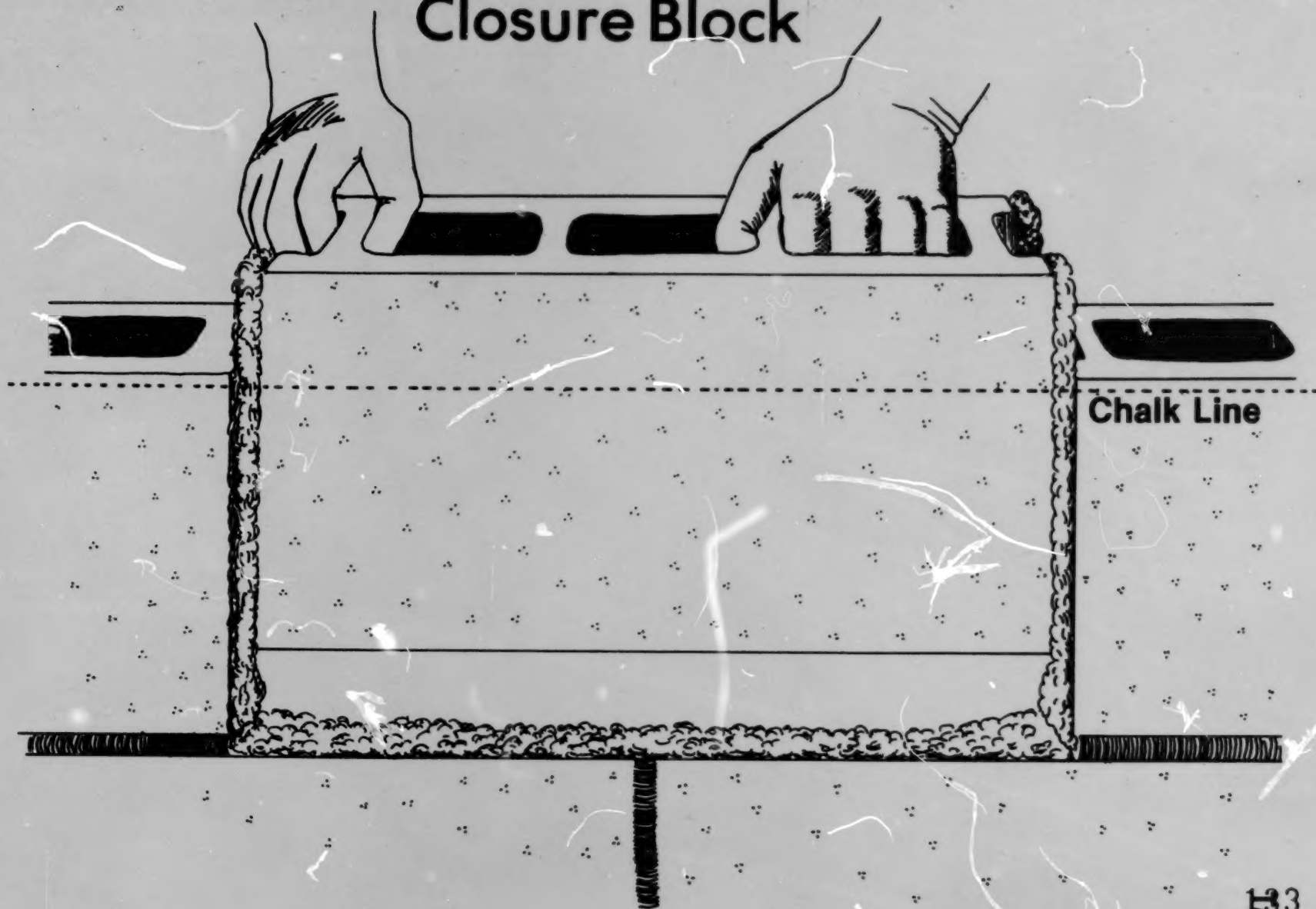


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TM-2
131

Closure Block



165

132

TM-3³

UNIT - WORKING WITH CONCRETE

Lesson 18 - Why and how are mortar joints tooled?

Objective: By the conclusion of the lesson, the student will be able to explain why mortar joints are tooled and the procedures for tooling a joint.

Study Questions:

1. What is the purpose of tooling mortar joints?
2. What tools are needed to complete the task?
3. What is the procedure for tooling mortar joints?

Reference:

1. Recommended Practices for Building with Concrete Masonry, Agricultural Engineering Department, University of Illinois, Urbana, Illinois 61801.

Transparencies:

1. TM #1: Jointer's Tools
2. TM #2: Tooling Horizontal Joint
3. TM #3: Tooling Vertical Joint

UNIT - WORKING WITH CONCRETE

Lesson 18 - Why and how are mortar joints tooled?

TEACHING PROCEDURE

- A. Review the proper placement of blocks in a mortar bed.
- B. Motivation - Discuss the advantages of tooling the mortar joints which are watertight, beauty, and strength. List the factors on the board.
- C. Assignment
- D. Supervised Study - Tool all the joints on the wall and corners already constructed in earlier lessons.
- E. Discussion

1. Tooling is an important part of the construction of a wall. Why is it so important?

What is the purpose of tooling mortar joints?

- 1) Compresses the mortar in the joints
- 2) Forces mortar up tightly against edges of blocks
- 3) Assumes watertight joints
- 4) Provides a smooth neat joint
- 5) Produces uniform appearance with sharp, clean lines

2. The tools used to tool the mortar joints are easy to make or are available from hardware dealers. What factors should be considered when purchasing? See TM #1.

What tools are needed to complete the task?

- 1) Jointers should be 22 inches long.
- 2) The end should be upturned to prevent gouging.
- 3) A handle is needed to make it easy to handle.
- 4) For concave joints, use a 5/8-inch round bar type.
- 5) For V-shaped joints, use a 1/2-inch square bar type.
- 6) For the vertical joints, use an S-shaped jointer.

3. After the tooling equipment has been gathered, the mortar should be "thumb-print" hard before tooling. Be careful not to press too hard causing a block to move. This action will weaken the joint. See TM #2.

What is the procedure for tooling mortar joints?

- 1) Tool the horizontal joints first.
- 2) After the horizontal joints are done, tool the vertical with the S-shape jointer.
- 3) Remove mortar burrs with a trowel or burlap bag.
- 4) Use sufficient pressure to compact mortar only, do not push too hard which might allow air to enter.

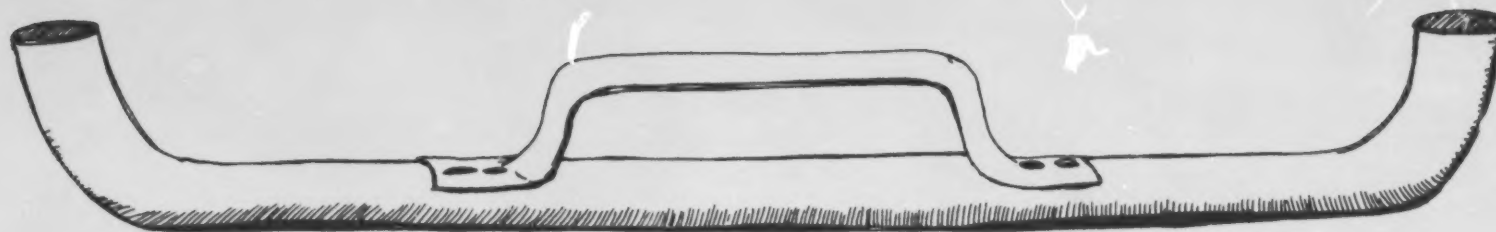
F. Summary

Tooling is important to insure a clean, watertight wall with sufficient strength to complete the job for which it was intended.

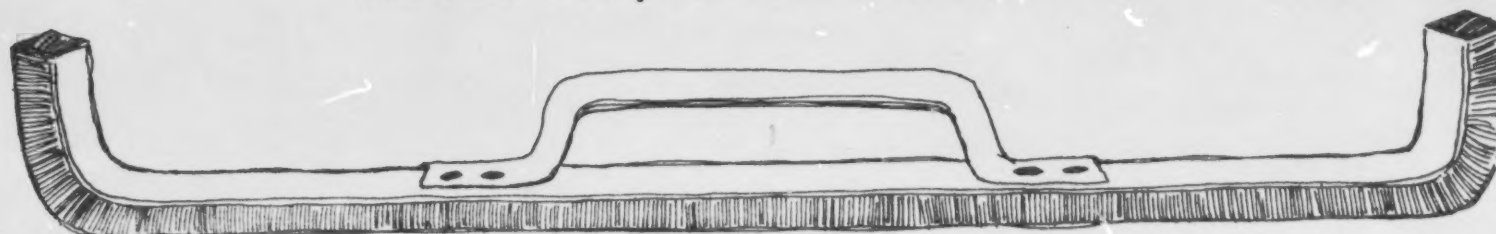
G. Evaluation

Tool the joints on the wall constructed earlier to the satisfaction of the instructor.

Jointer's Tools



Round Shaped Horizontal Joint



V-Shaped Horizontal Joint



S-Shaped Vertical Joint

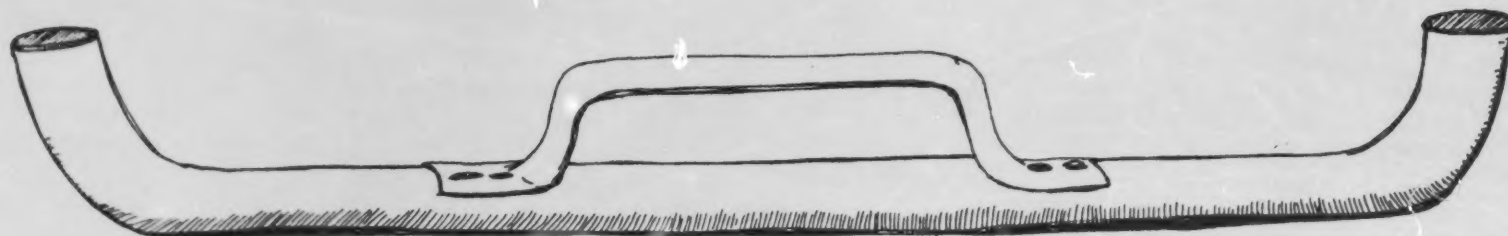
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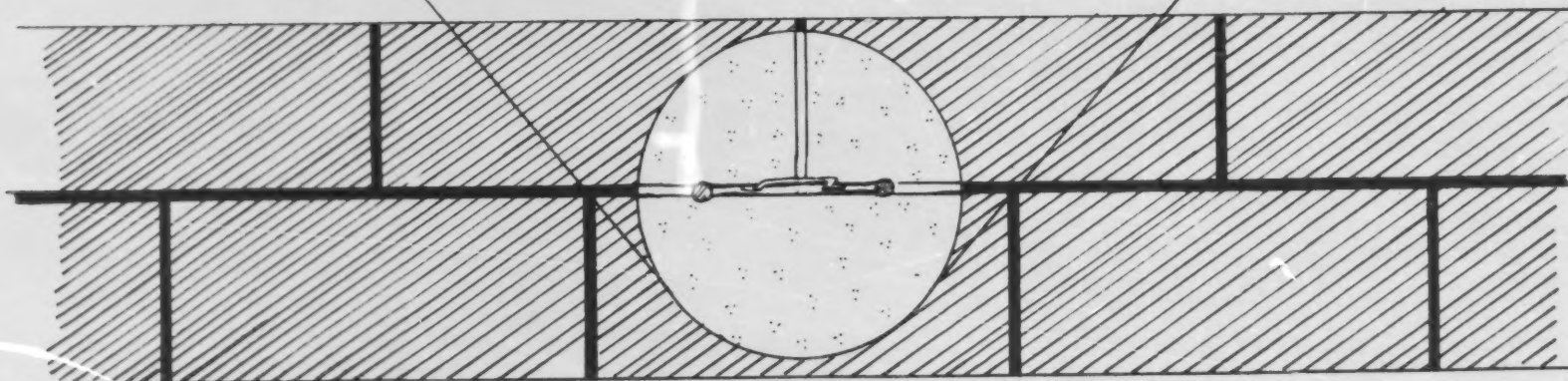
TW-1

138

Tooling Horizontal Joint



173



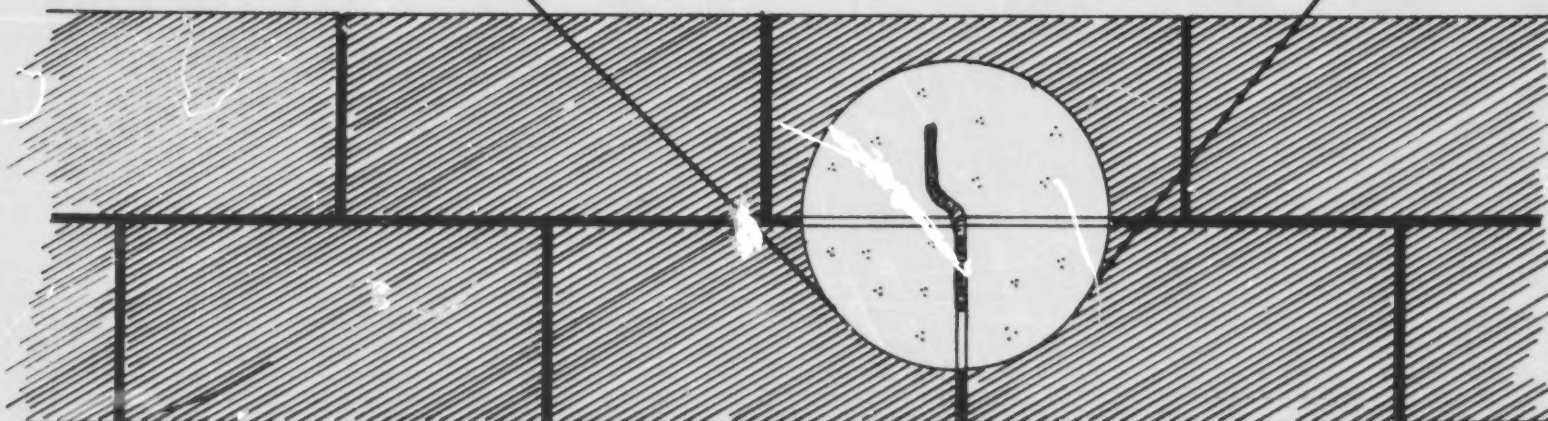
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TM-2
140

Tooling Vertical Joint



175



TM-3

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141

UNIT - WORKING WITH CONCRETE

Lesson 19 - What special applications are important to concrete masonry?

Objective: By the conclusion of the lesson, the student will be able to set anchor bolts, plan drainage, and protect the walls.

Study Questions:

1. How are anchor bolts installed?
2. What foundation drainage is needed?
3. How are the masonry walls protected from weather?
4. When are control joints used in concrete masonry?
5. How are block walls insulated?

Reference:

1. Recommended Practices for Building with Concrete Masonry, Agricultural Engineering Department, University of Illinois, Urbana, Illinois 61801.

Transparencies:

1. TM #1: Anchor Bolt
2. TM #2: Masonry Wall Needs

UNIT - WORKING WITH CONCRETE

Lesson 19 - What special applications are important to concrete masonry?

TEACHING PROCEDURE

A. Review

- B. Motivation - How are wood walls attached to block walls? How are walls protected from water absorption? What do control joints do in a wall?

- C. Assignment - Locate a wall on your farm which has anchor bolts or control joints. Report back to the class as to where in the building they are used.

- D. Supervised Study - Have each class member set an anchor bolt.

E. Discussion

1. The use of anchor bolts in concrete masonry is an important step in construction. The anchor bolts prevent the shifting of a structure in the wind. See TM #1.

How are anchor bolts installed?

- 1) Wood plates are attached using 1/2-inch, 18 inch long bolts.
 - 2) Spacing is not more than four feet apart.
 - 3) Bolts are set in the core of the top two courses of block with mortar or concrete.
 - 4) Plan ahead by placing metal lath between second and third course from top to stop mortar fill.
 - 5) Bolts should protrude enough to penetrate wood plate plus 3/4-inches.
2. Excessive water will reduce the ability of soils to hold weight properly. To correct this problem a drainage system is needed in the preplanning stages. See TM #2.

What foundation drainage is needed?

- 1) Place drain tile beside footing.
- 2) To prevent backwashing drain to an outlet which is always open.
- 3) Place tile 1/4-inch apart along wall.
- 4) Cover with 2 to 4 feet of gravel to facilitate water movement.

3. Although masonry walls are strong, they have the ability to absorb large amounts of water. Too much water can cause the blocks to sweat and possibly weaken the mortar if it is during construction. See TM #2.

How are the masonry walls protected from weather?

- 1) During construction cover the work and blocks not used with a waterproof cover at the end of the day.
 - 2) The earth side of concrete masonry basement walls should be plastered with a 1/2-inch coat of Portland cement plaster or excess mortar.
 - 3) Dampen the wall first to keep the wall from drawing water out of the plaster.
 - 4) Apply plaster in two coats at 24-hour intervals. Score the first coat to facilitate the bonding of the second.
 - 5) If soil is wet and poorly drained, grout the plaster surface with cement-sand mixture applied over the damp plaster.
4. Walls are subject to many stresses which can cause cracks in a wall. Who in the class has seen a wall with a crack running through it? Draw a comparison to the control joints in concrete slabs.

When are control joints used in concrete masonry?

- 1) Used to control movements from various stresses
 - 2) They are continuous vertical joints in the walls.
 - 3) Protect the wall from uneven loads or settling.
5. Block walls do not have high insulating values. To improve the insulating value of a block wall, what can be done?

How are block walls insulated?

- 1) Fill cores of blocks with granular insulating material.
- 2) Place rigid insulation over furring strips attached to inside walls.

F. Summary

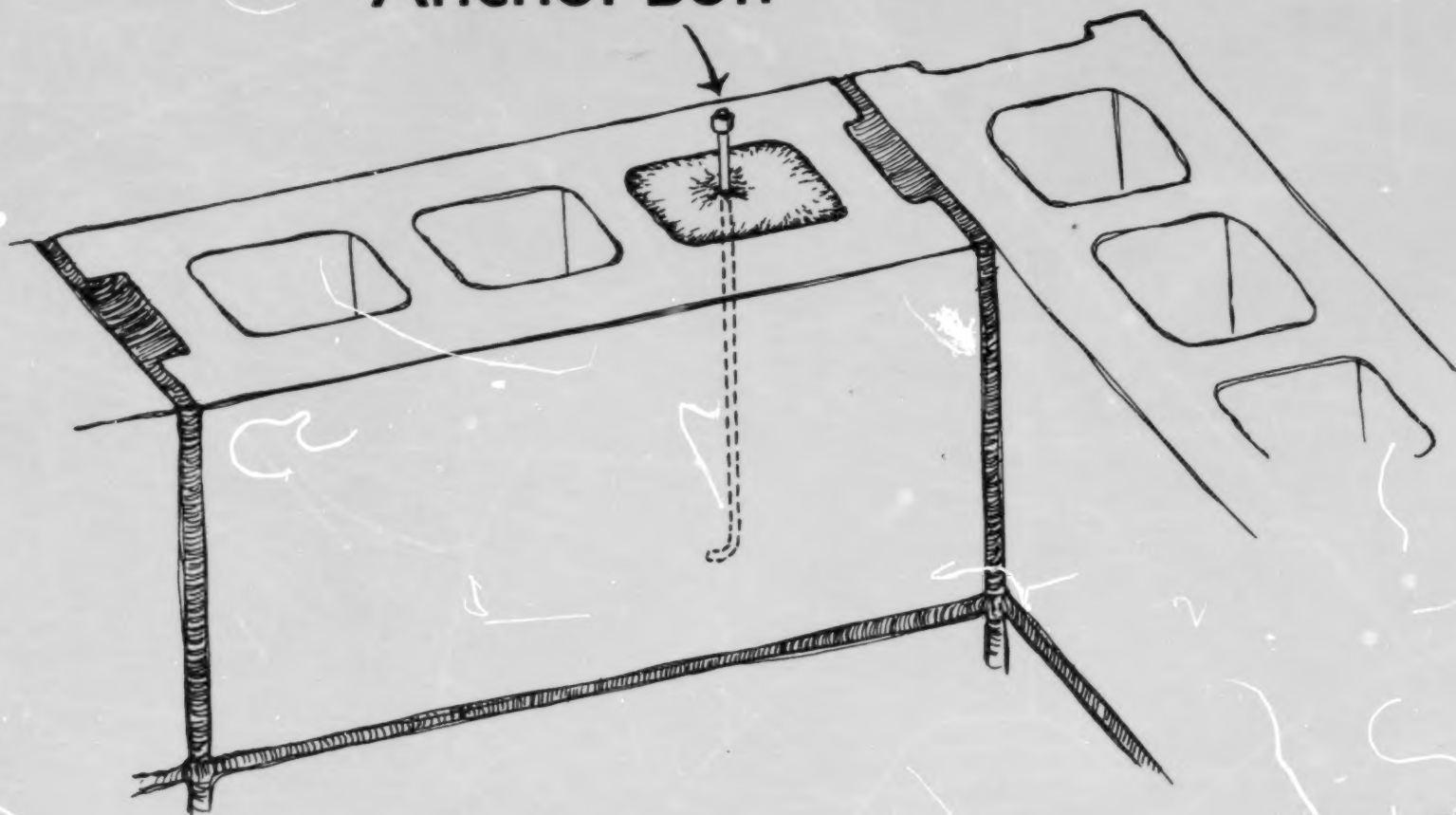
Anchor bolts are used in masonry to hold the wall sections in place adding strength to the entire structure. Care must be taken during construction to prevent excessive moisture absorption by the blocks. By dampening the blocks it allows the mortar and plaster

to bond more securely by limiting water absorption.
The moisture is needed for the chemical bonding action
of the mortar and plaster.

G. Evaluation

Have the students set an anchor bolt in the masonry
wall.

Anchor Bolt



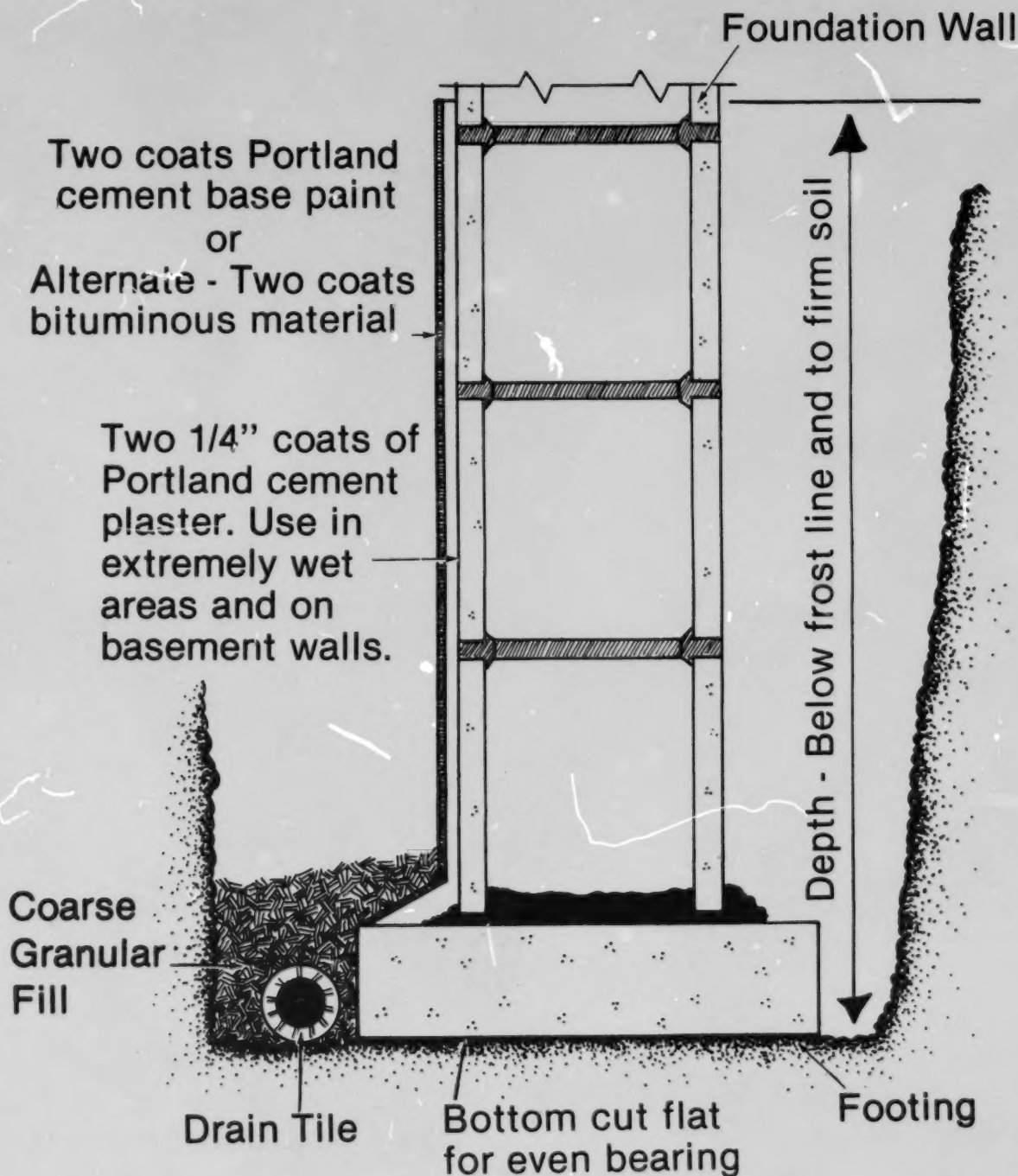
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TM-1

148

Masonry Wall Needs



UNIT - WORKING WITH CONCRETE

LABORATORY EXERCISE

Objective: By the conclusion of the exercise, the student will be able to mix mortar, construct a first course, construct a corner, set dimensions for windows and doors, and construct eight courses of block.

Tools Needed:

1. Trowels
2. Mixing equipment
3. Tooling irons
4. Chalk line
5. Levels
6. Ruler

Materials Needed:

1. Mortar - Portland cement
hydrated lime
sand
water
_____ line blocks 8 feet by 8 feet by 16 feet
_____ corner blocks 8 feet by 8 feet by 16 feet
_____ half-corner blocks
_____ window-slotted blocks
2. 2 - 1/4-inch by 3 inches by 3 inches by 56 inches angle
iron for door lintel
3. 2 - 1/4-inch by 3 inches by 3 inches by 64 inches angle
iron for window lintel
4. Handout #1: Block Corner

Procedure:

PART 1: MORTAR MIX

Step 1: Mix together mortar at the rate of a 1/2-cubic foot at one time.

Ingredients:

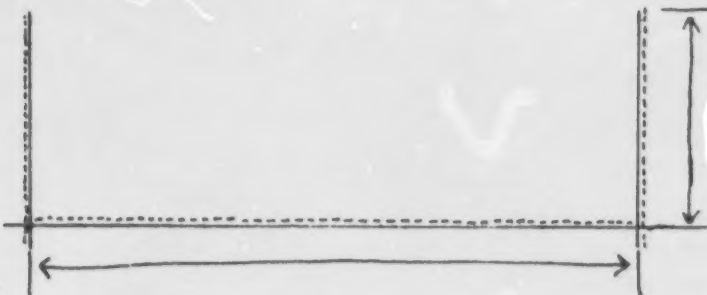
- 1 part Portland cement
- 2 parts hydrated lime
- 4 parts sand
- enough water for proper consistency

Evaluation Part 1:

- 1) Is mixture plastic? _____
- 2) Will mixture adhere to trowel? _____
- 3) Is mixture watery? _____
- 4) Are all parts thoroughly mixed? _____

PART 2: CONSTRUCTING THE FIRST COURSE

- Step 1: Mark off the corners of the wall. The wall will be U-shaped with the following dimensions 4 feet by 12 feet 8 inches by 4 feet.
- Step 2: Lay out the run of the first course with the chalk line.



- Step 3: Lay out the blocks needed for the first course without mortar.



- Step 4: Prepare a mortar bed for the first course in a V-pattern along the inside of the chalk line.



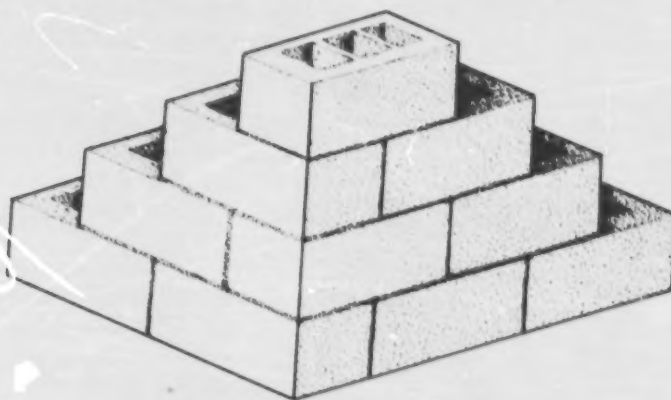
Step 5: Construct the first course, 3/8-inch mortar joints. Use a ruler to check the size of the mortar joints while laying the block.

Evaluation Part 2:

- 1) Corners square? _____
- 2) Proper blocks used? _____
- 3) Mortar bed laid properly? _____
- 4) Chalk line made properly? _____
- 5) First course level? _____

PART 3: CONSTRUCTING CORNERS

Step 1: The building will have eight courses of block, but you will only set a four course corner. See HO #1.



Step 2: The corners will not be full on the right side because of the location of the door which is one block from the corner.

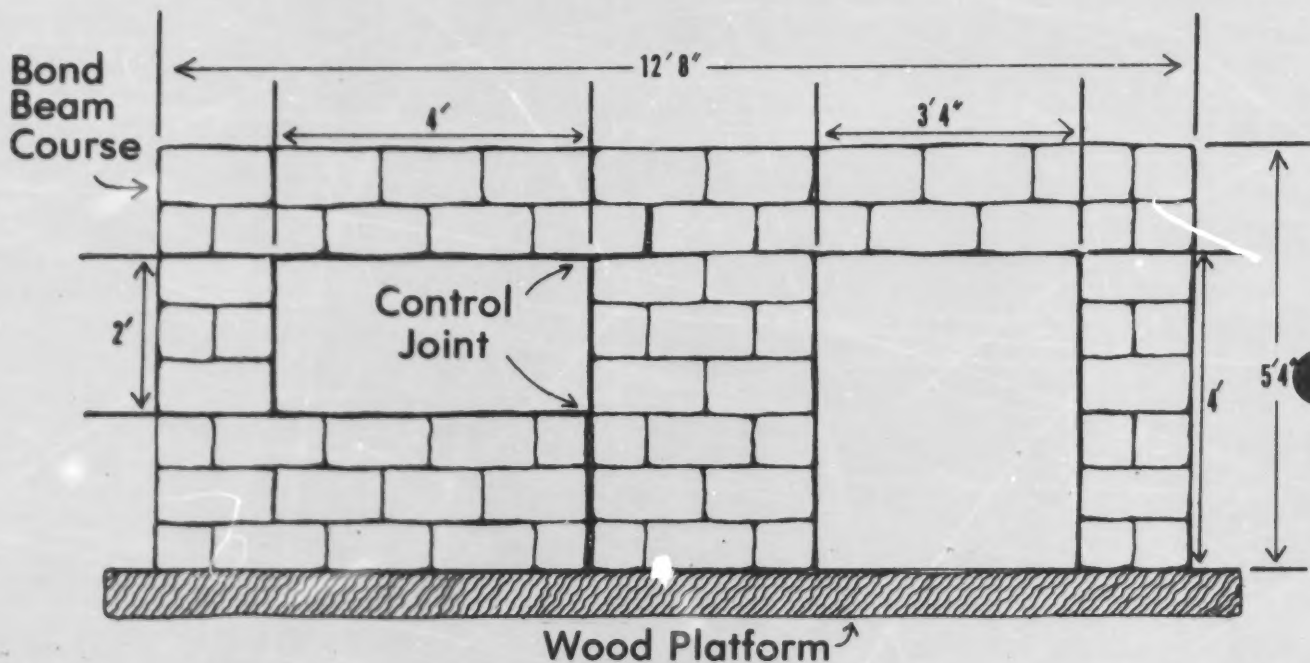
Step 3: Follow the drawing and set both corners.

Evaluation Part 3:

- 1) Were corner blocks used? _____
- 2) Were the blocks buttered properly? _____
- 3) Was a proper mortar bed set on each course? _____
- 4) Was each course checked for:
 - a) Horizontal spacing? _____
 - b) Vertical spacing? _____
 - c) Plumb? _____
 - d) Level? _____
- 5) Are all mortar joints 3/8-inch? _____

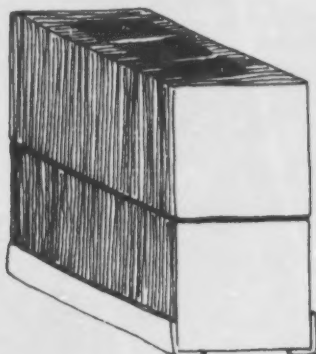
PART 4: CONSTRUCTING THE WALL

- Step 1: Check the blocks for sufficient corner and window blocks to complete the assignment.
- Step 2: Check mortar supply.
- Step 3: The front should have:
- 1) Window 4 feet by 2 feet
 - 2) Door 3 feet 4 inches by 4 feet
 - 3) Control joint from foundation, to side of window to bond beam course.



- Step 4: For the window, use window slotted blocks:
- 1) 2 - window slotted and corner combo
 - 2) 2 - window slotted and stretcher combo
 - 3) 2 - half-size window slotted and corner combo
- Step 5: For the door use corner blocks:
- 1) 6 - full-size corner blocks (both ends)
 - 2) 6 - half-size corner blocks

Step 6: Before constructing course seven, place the angle iron over the window and door openings to support the last two courses.



Step 7: Remember to place the control joint in course seven.

Step 8: Tool all the mortar joints.

Evaluation Part 4:

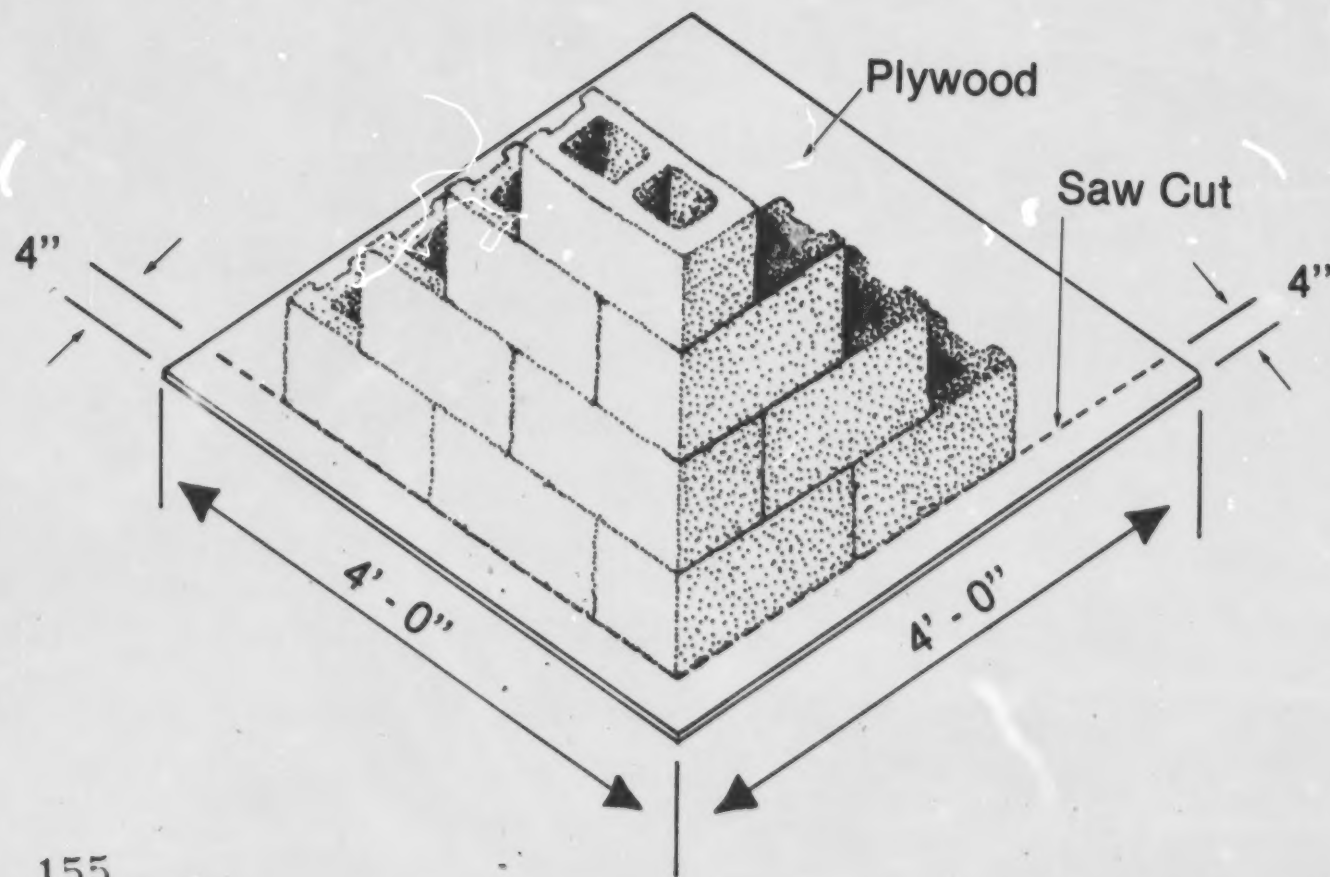
- 1) Was each course checked for:
 - a) Horizontal spacing? _____
 - b) Plumb? _____
 - c) Level? _____
 - d) Mortar-joint size? _____
 - e) Vertical spacing? _____
- 2) Was mortar sufficiently set before tooling? _____
- 3) Were ledge supports set properly? _____
- 4) Are windows and doors the specified size?
 - a) Windows? _____
 - b) Doors? _____

PART 5: CLEAN UP

Step 1: The mortar mixture used will break apart easily. With the trowel tap each block loose and remove. Clean excess mortar from the faces of each block and set the block aside.

Step 2: The excess mortar and mortar removed can be reused by adding water if it is to be used immediately or setting it in a well-drained area outside and let the rain remove the cement and lime from the sand. The sand is reusable.

Block Corner



192

155

156

HO-1

UNIT - WORKING WITH CONCRETE

LABORATORY EXERCISE

Objective: At the conclusion of the lesson, the student will be able to mix a batch of concrete and complete a concrete project.

Introduction: Follow carefully in sequence the instructions for completing the laboratory exercise. Have all materials gathered before starting any procedures.

Materials Needed:

1. Portland cement
2. Water: clean and mineral free
3. Sand: screened through a No. 4 screen
4. Coarse aggregate: gravel cleaned

Tools Needed:

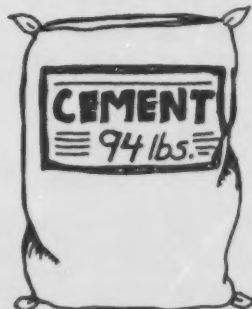
1. Mixing pan
2. Blunt-nosed trowel
3. Scales
4. Eight-ounce measuring cup
5. Slump mold
6. Casting mold

Transparencies:

1. TM #1: Concrete Beam Tester
2. TM #2: Concrete Beam Form

Procedure:

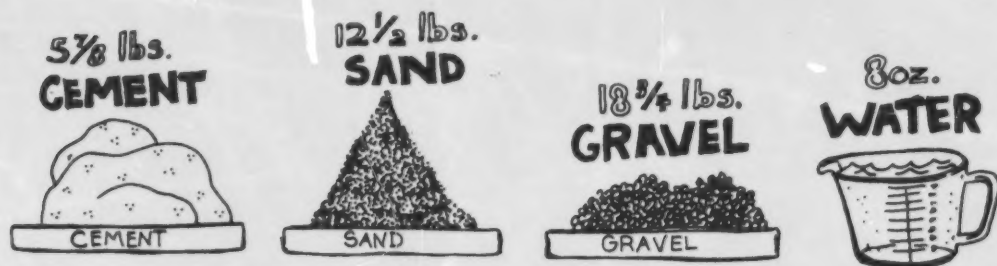
- Step 1:** In order to demonstrate mixing concrete, make a 1:2:3 6-gallon mix which is a standard mix with:
- a) One cubic foot of cement (one sack) (94 lbs.)
 - b) Two cubic feet of sand (200 lbs.)
 - c) Three cubic feet of gravel (300 lbs.)
 - d) Eight cubic feet of water (6 gallons)



Step 2: For demonstration purposes we will be making a 1/16-sack mix. Measure out the following:

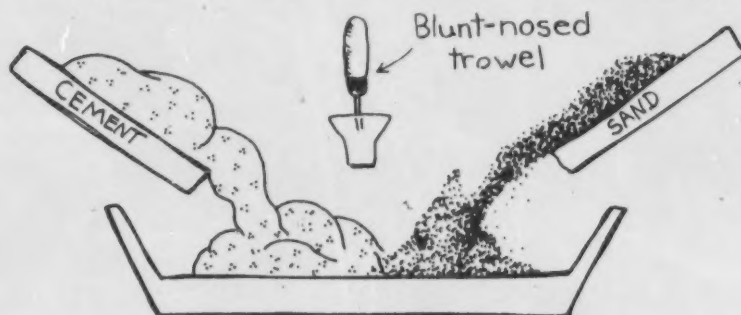
- a) 5 7/8 pounds of cement
- b) 12 1/2 pounds of sand
- c) 18 3/4 pounds of gravel
- d) Eight-ounce cup of water

NOTE: If the sand is wet, you must adjust for the moisture held in it. If damp, subtract 1/2-gallon water per 6 gallons of water; if average wet, adjust 1 gallon water per 6 gallons of water; and if very wet, subtract 1 1/2 gallons of water from the 6 gallons of water.



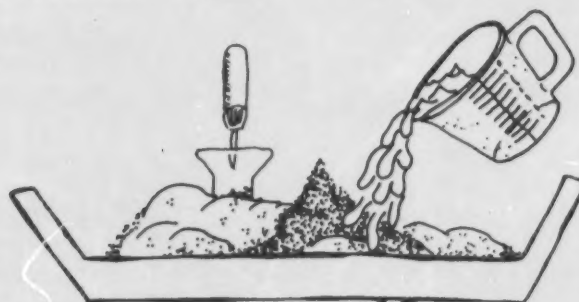
Step 3: Mix the sand and cement together.

5 7/8 pounds cement + 12 1/2 pounds sand

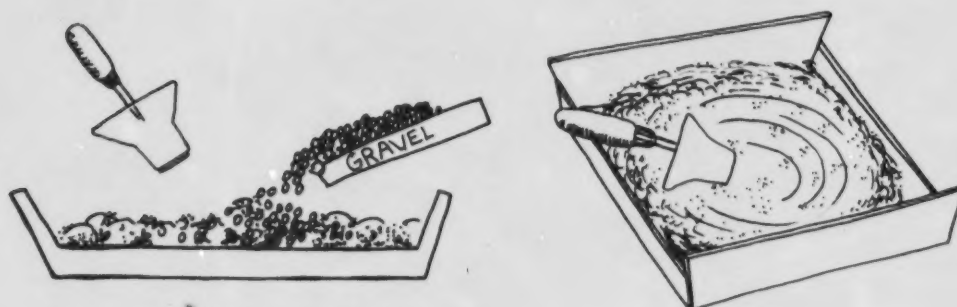


Step 4: Make a crater in sand-cement mixture; add ALL the water. Mix thoroughly with the trowel.

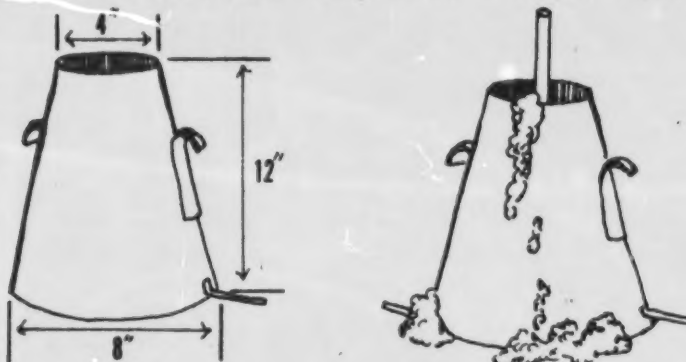
(5 7/8 pounds cement + 12 1/2 pounds sand)
+ 8 ounces water



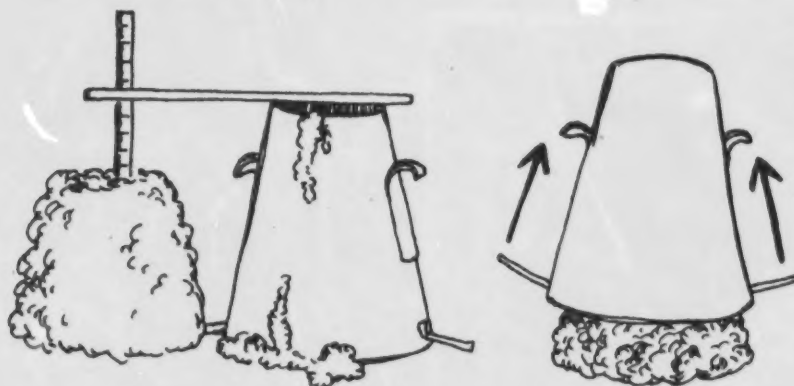
Step 5: Add the aggregate slowly, working it in until the mixture is workable (60-70% aggregate). Test workability by smoothing the surface until no gaps or holes are present.



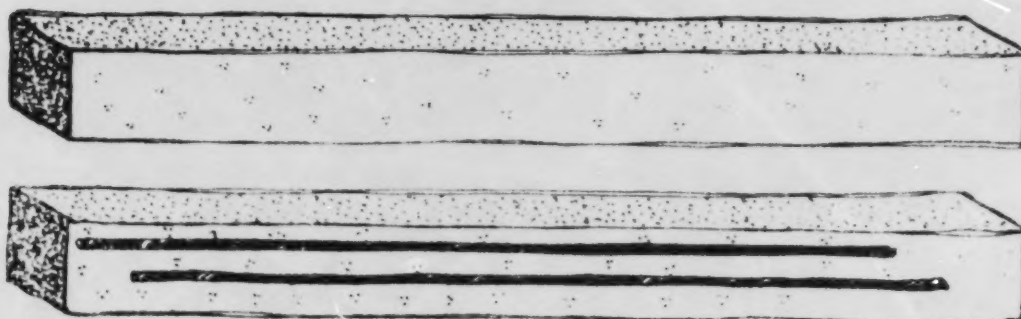
Step 6: Using the slump mold (12" x 4" x 8"), fill the mold with the mixture and tamp with a steel rod.



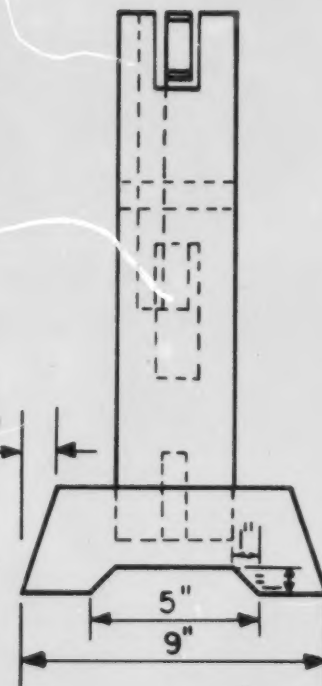
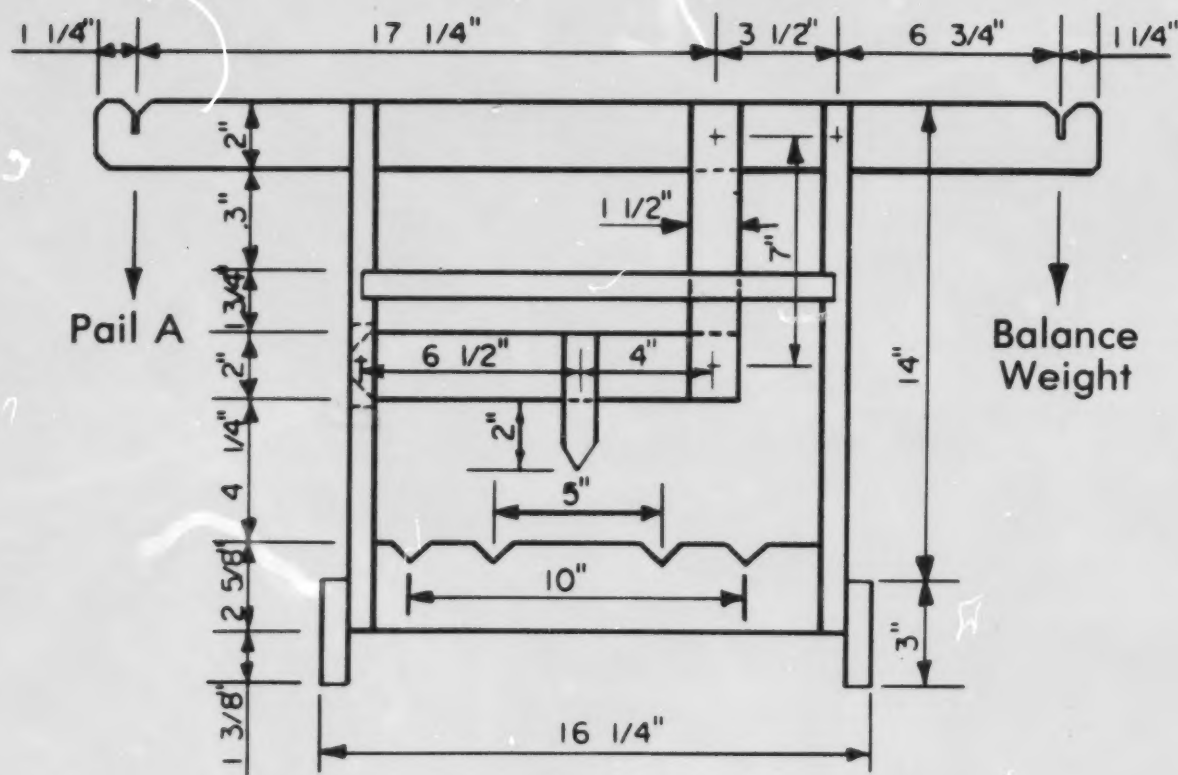
Step 7: Remove the mold slowly and place the mold beside the slumping concrete. Measure the height difference of the mold and slumping concrete. If the slump is over 3 to 4 inches, remix.



- Step 8: After the slump has been tested, either place the mixture into a small slab form for finishing or place beams to be tested for strength.
- Step 9: Place two beams. One beam will contain reinforcing rod 1/4-inch in the load bearing portion of the beam. The second beam will contain no reinforcing material. Test strength of these two beams by applying pressure with a hydraulic press. (See TM #1.)



Concrete Beam Tester

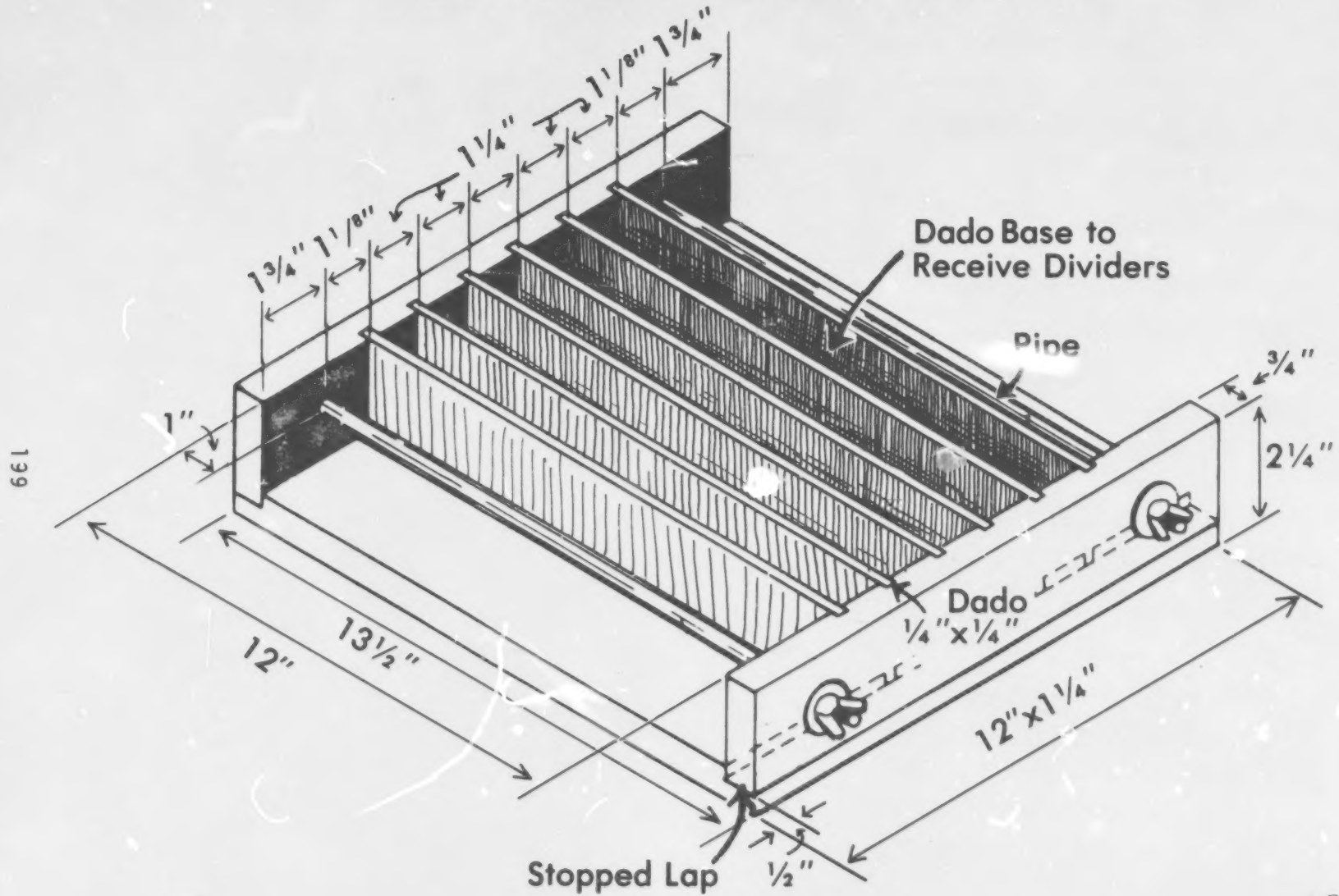


161

162

TW-1

Concrete Beam Form



139

163

164
TMA-2

UNIT - DRAWING AND PLAN READING

Lesson 1 - What instruments are used to draw plans?

Objective: After the completion of this lesson, the student will be able to identify drawing instruments.

Study Questions:

1. What marking instruments are used to make drawings?
2. What surfaces are used to assure smooth drawings?
3. What instruments are used to make angles and lines?
4. What instruments are used to scale drawings and mark distances?

References:

1. Modern Agricultural Mechanics, by T.J. Wakeman. The Interstate Printers and Publishers, Danville, Ill.
2. Shopwork on the Farm, by Mack M. Jones, McGraw-Hill Rural Activities Series.
3. The Use and Care of Drawing Instruments, No. 9255, by Eugene Dietzgen Co., c/o The Ruckert Co., 2800 Clark St., St. Louis, Mo. 63103. n/c

Transparencies:

1. TM #1: Pencils
2. TM #2: Instruments
3. TM #3: Scales

UNIT - DRAWING AND PLAN READING

Lesson 1 - What instruments are used to draw plans?

TEACHING PROCEDURE

A. Review

- B. Motivation - Show the class examples of drawings to spark interest. Show the equipment used and ask members of the class to try to identify each item.

C. Assignment

- D. Supervised Study - Conduct a pretest on instrument identification. Then go through the correct answers with the class holding each instrument up and discussing its function.

E. Discussion

1. Depending on the quality of your drawing equipment, you will use either pencil or ink to make the drawings. In most agriculture programs pencil sketching will predominate. See TM #1.

What marking instruments are used to make drawings?

- 1) Pencils come in 18 different grades of hardness.
 - 2) Medium hard, 4H, used for mechanical drawing
 - 3) 1H and 3H are preferred for lettering and sketching
 - 4) Medium soft B, HB and F for freehand work
 - 5) Sharpen for the job
 - a) Flat chisel-shaped point for straight lines
 - b) Conical-shaped point for sketching and lettering
 - 6) Ink drawing is difficult, time consuming, and requires special equipment.
2. The quality of the work surface and paper is of extreme importance to the drafter. Store boards and paper carefully to prevent damaging surfaces. See TM #2.

What surfaces are used to assure smooth drawings?

- 1) Drawing boards
 - a) Flat, smooth surface
 - b) Convenient size is 18 x 24 inches.
 - c) Made of a soft wood
 - d) Left edge perfectly straight to accommodate T-square

- 2) Drawing paper
 - a) Good quality - high rag content
 - b) Grain sufficient to take pencil, ink, and good erasing qualities
3. There are basic instruments used to calculate angles and make straight lines. With these instruments most basic angles used in drawing can be made. See TM #2.

What instruments are used to make angles and lines?

- 1) T-square
 - a) Used to draw horizontal lines
 - b) Guide for triangles in drawing vertical and sloping lines
 - c) Use only the upper edge of the square
 - d) Generally draw left to right
 - e) Used to align paper for taping
- 2) Triangles
 - a) Used for vertical and sloping lines
 - b) 45° type has two 45° angles and one 90° angle
 - c) 60° type has one 60° angle, one 30° angle, and one 90° angle
 - d) Can be of various sizes 6 inch 45° and 10 inch 60° are common
 - e) Together they can set any angle divisible by 15
- 3) Protractor
 - a) Measures the degree of angles
 - b) Checks angles drawn
 - c) Used to set angles not divisible by 15
4. Due to the size of most projects in structures, it is not possible to draw the project in its true size. What is used is a scale which sets each part as a proportion of the finished size. See TM #3.

What instruments are used to scale drawings and mark distances?

- 1) In technical drawing the word scale is used in place of ruler.
- 2) Scale does two things.
 - a) Measures
 - b) Has markings of proportion
- 3) Two kinds of scales
 - a) Flat
 - b) Triangular
- 4) Two styles of scales
 - a) Engineer's
 - b) Architect's
- 5) Engineer's scale has inch divisions divided into decimals of an inch.
- 6) Architect's scale is subdivided.
 - a) Inches
 - b) 1/2-inch

- c) 1/4-inch
- d) 1/8-inch
- e) 1/16-inch
- 7) The architect's scale is also divided to proportionalize a drawing. The label on the end indicates the number of inches per foot of finished product. Common dimensions include:
 - a) 1/8-inch = 1/96 size
 - b) 1/4-inch = 1/48 size
 - c) 1/2-inch = 1/24 size
 - d) 3/4-inch = 1/16 size
 - e) 1 inch = 1/12 size
 - f) 3 inches = 1/4 size
- 8) Compass to draw circles, arcs, ellipses
- 9) Dividers to transfer measurements and spacings
- 10) Bow instruments are used for measurement of under one inch, better accuracy.

F. Summary

Investing in quality instruments will be rewarded by quality work. Proper care and use will make drawing easier and more accurate in the long run.

G. Evaluation

The evaluation of this lesson should be an identification test of the instruments. Hold each instrument up before the class and have them name it and its use.

Pencils



Conical Point



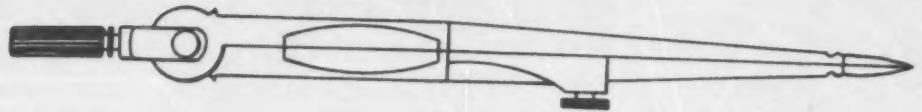
Flat Chisel Point

Instruments



Protractor

Dividers



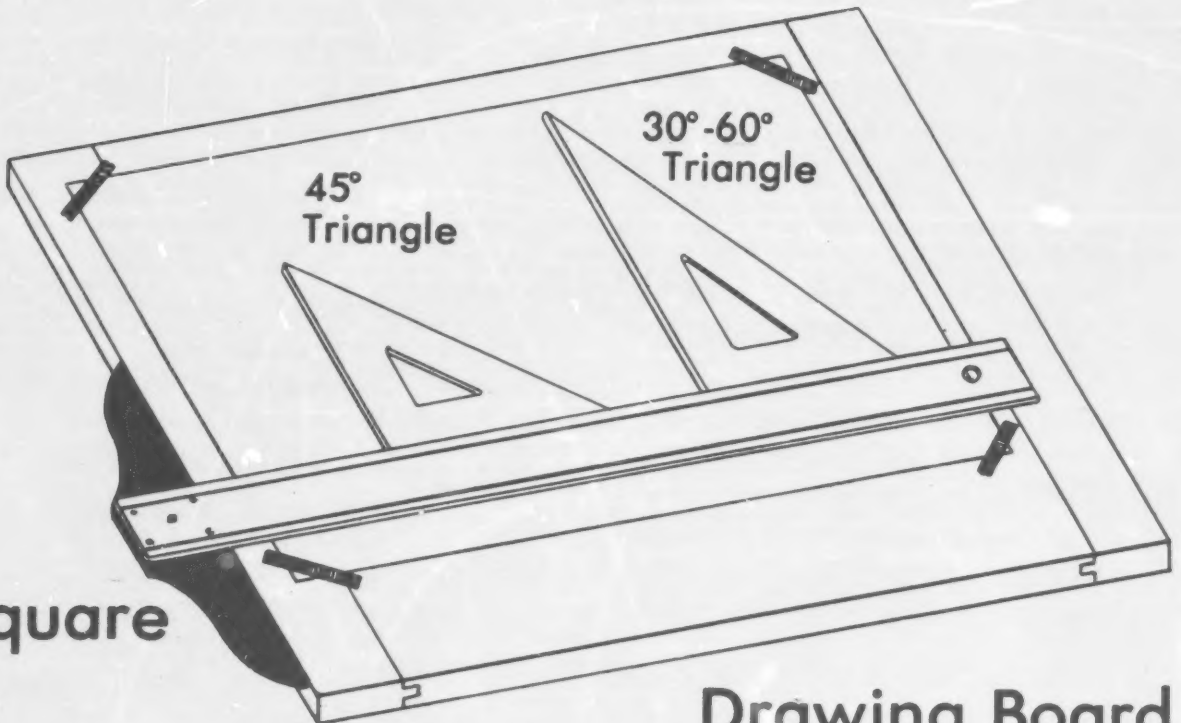
**Bow
Pencil**



**Bow
Pen**



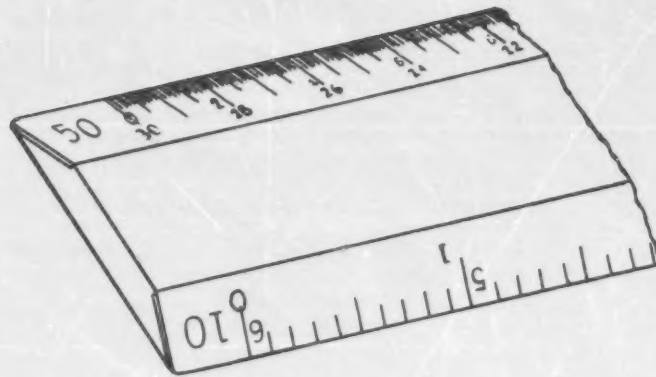
**Bow
Dividers**



T-Square

Drawing Board

Scales



Engineer's Scale-flat



Architect's Scale-triangular

UNIT - DRAWING AND PLAN READING

Lesson 2 - What basic procedures are important to mechanical drawing?

Objective: After the completion of this lesson, the student will be able to set up for drawing, identify the line types and their uses, lay out the margins and title block, and use the instruments to set angles.

Study Questions:

1. What procedure is followed to set up for drawing?
2. What are the line types and their uses?
3. How are the margins and title block laid out on the paper?
4. How are the instruments used to set angles?

References:

1. Modern Agricultural Mechanics, T.J. Wakeman, The Interstate Printers and Publishers, Danville, Ill.
2. Shopwork on the Farm, Mack M. Jones, McGraw-Hill Book Co.
3. The Use and Care of Drawing Instruments, No. 9255, by Eugene Dietzgen Co., c/o The Ruckert Co., 2800 Clark St., St. Louis, Mo. 63103. n/c

Transparencies

1. TM #1: Set Up
2. TM #2: Lines
3. TM #3: Labeling
4. TM #4: T and 45° Triangle
5. TM #5: T and 60° Triangle
6. TM #6: T and Both Triangles

UNIT - DRAWING AND PLAN READING

Lesson 2 - What basic procedures are important to mechanical drawing?

TEACHING PROCEDURE

- A. Review the instruments used to make lines.
- B. Motivation - Show the class the different line types in the blueprint of a farm structure. Then demonstrate the use of the T square, 45° triangle and 60° triangle to set angles.
- C. Assignment
- D. Supervised Study - Have the students practice setting up and making the different types of lines.
- E. Discussion
 1. The initial set up of the paper and equipment is important if quality work is to be obtained. See TM #1.

What procedures are followed to set up for drawing?

- 1)
 - a) Drawing board
 - b) T-square
 - c) Drafting tape
 - d) Ruler
 - 2) Place drawing board on a flat surface. (inclined) drawing table is acceptable if inclined surface is smooth and flat.
 - 3) Place a sheet of paper on the board leaving a 2-inch margin on the top and left side (right handed people). Opposite side for left handers. Use ruler to measure margin.
 - 4) Align the paper using the T-square on the lower edge of the paper.
 - 5) Tape the top two corners.
 - 6) Check alignment.
 - 7) Tape lower two corners.
2. When drawing an object to be built, we like to show hidden dimensions as well as exposed surfaces. The type of line drawn will help to clarify a drawing. See TM #2.

What are the line types and their uses?

- 1) Border
 - a) Very heavy line
 - b) Used to frame a drawing
 - c) H pencil

- 2) Object
 - a) Heavy line
 - b) Shows visible edges
 - c) 2H pencil
 - 3) Hidden
 - a) Medium line
 - b) Shows hidden edges
 - c) 2H pencil
 - 4) Dimension
 - a) Light line
 - b) Shows dimensions
 - c) 3H pencil
 - 5) Extension
 - a) Light line
 - b) Indicates the extent of a measurement given by a dimension line
 - c) 3H pencil
 - 6) Break
 - a) Heavy line
 - b) Shows short breaks
 - c) 2H pencil
 - 7) Break
 - a) Light line
 - b) Shows long breaks
 - c) 2H pencil
 - d) Differs from 6), looks like a tilted z
 - 8) Cutting plane
 - a) Very heavy line
 - b) Shows cutting plane
 - c) H pencil
 - 9) Center line
 - a) Very light line
 - b) Shows centers
 - c) 3H pencil
3. To individualize each drawing, it is suggested to label each with a title block. This block is important for grading and transition from paper to the item being constructed. See TM #3.

How are the margins and title block laid out on the paper?

- 1) Margins - drawn with a very heavy line, the T-square and 60° triangle
 - a) Horizontal margins - 1/4-inch lower, 1/2-inch upper using the T-square as a straight edge
 - b) Vertical margins - 1/4-inch left and right using the triangle resting on the T-square to draw the lines
- 2) Title block contains the following:
 - a) School
 - b) Drawn by
 - c) Scale used
 - d) Title
 - e) Date

- f) Class
- g) Seat
- h) Drawing number
- 3) Dimensions of the title block
 - a) 5/8-inch deep, the length of the bottom of the paper; border and divide using a very heavy line.
 - b) Left to right, the first box of the block is 3 1/2 inches long with the school name in the upper 3/8-inch and drawn by; (DR.BY:) in lower 1/4-inch.
 - c) Next to b) in the next 4 inches horizontally in section 2, the upper 3/8-inch put the title of the drawing, in the lower 1/4-inch put the scale and date.
 - d) Next to c) in the next horizontal inch put the class.
 - e) Next to d) in the next horizontal inch put the seat number.
 - f) Next to e) in the next horizontal inch put the drawing number.

4. To make an angle on the drawing, the student must be able to utilize the T-square and triangles. The combination of the three will produce any angle divisible by 15 degrees.

How are the instruments used to set angles?

- 1) The T-square will form 180° angles.
- 2) T-square and the 45° triangle can produce. See TM #4.
 - a) 90° angle
 - b) 45° angle or 135° angle
- 3) T-square and 60° triangle can produce. See TM #5.
 - a) 90° angle
 - b) 60° angle or 120° angle
 - c) 30° angle or 150° angle
- 4) T-square and both triangles can produce. See TM #6.
 - a) 15° angle and 165° angle
 - b) 75° angle and 115° angle

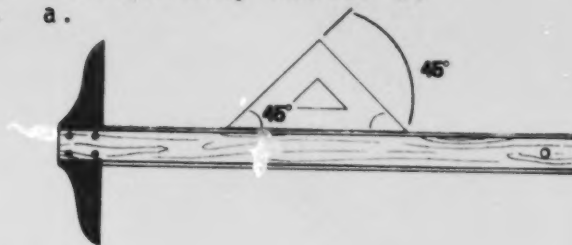
F. Summary

Proper placement of the paper and preparation of design surface is important to the quality of the finished product. In addition, by manipulating the T-square and triangles, any angle divisible by 15 degrees can be drawn.

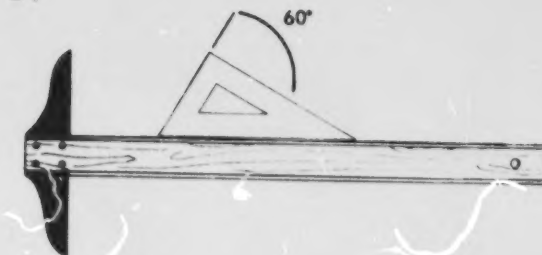
G. Evaluation

Answers to the Exam

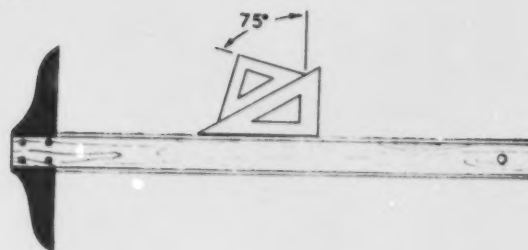
1. Transparency Master #3
2. a.



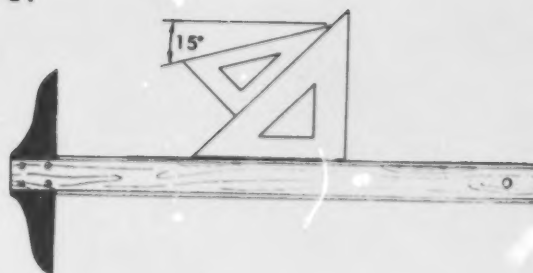
b.



c.



d.



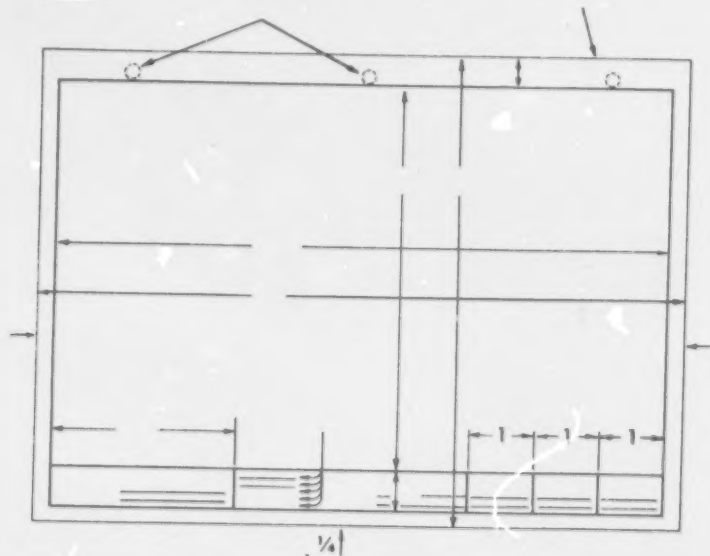
176

UNIT - DRAWING AND PLAN READING

Lesson 2 - What basic procedures are important to mechanical drawing?

EXAM

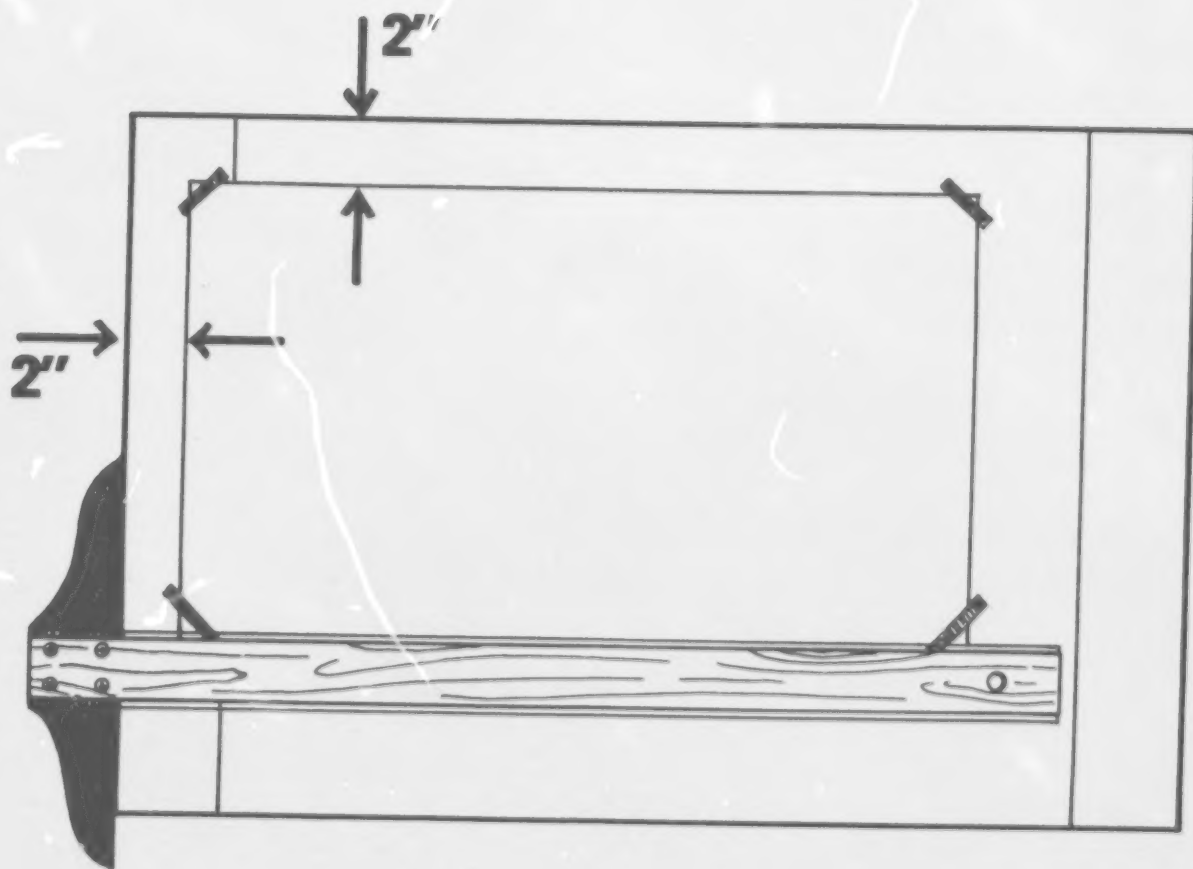
1. Label the parts and dimensions on the drawing paper below. Complete the title block.



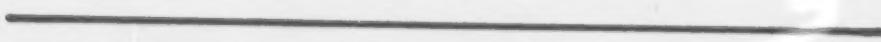
2. Using the T-square, 45° triangle, and 60° triangle, draw how you would find the following angles.

- a. 45° angle
- b. 60° angle
- c. 75° angle
- d. 15° angle

Set Up

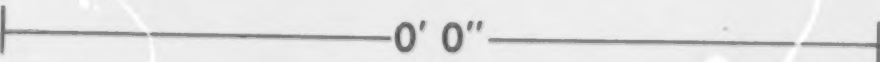


Lines


BORDER


OBJECT


HIDDEN


DIMENSION


EXTENSION


BREAK


BREAK



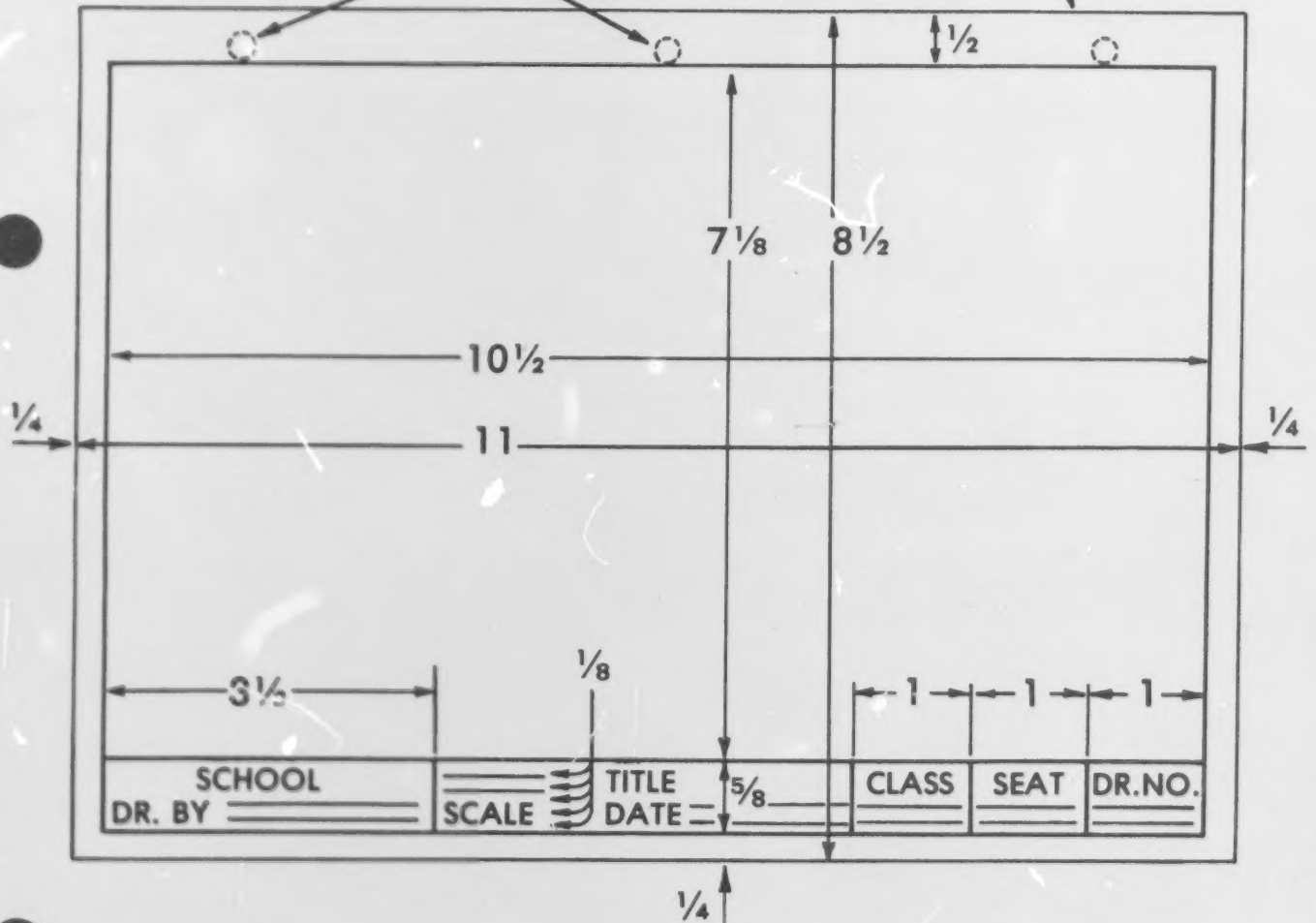
CUTTING PLANE


CENTER LINE

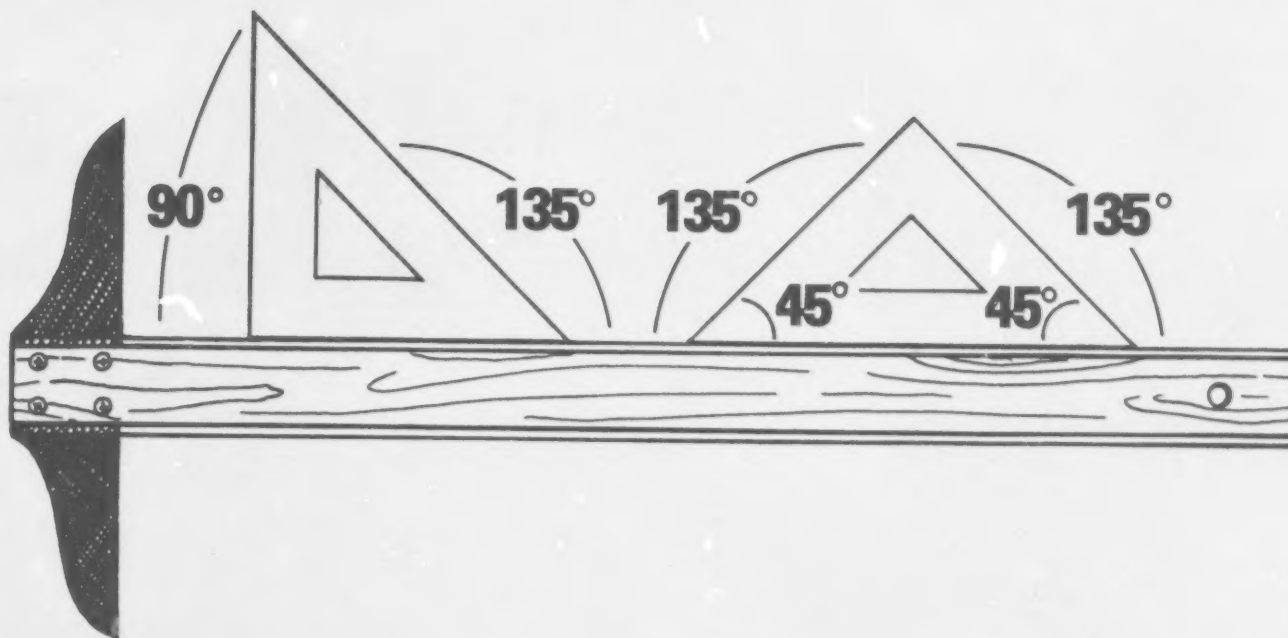
Labeling

PUNCH FOR LOOSE-
LEAF NOTEBOOK
IF DESIRED

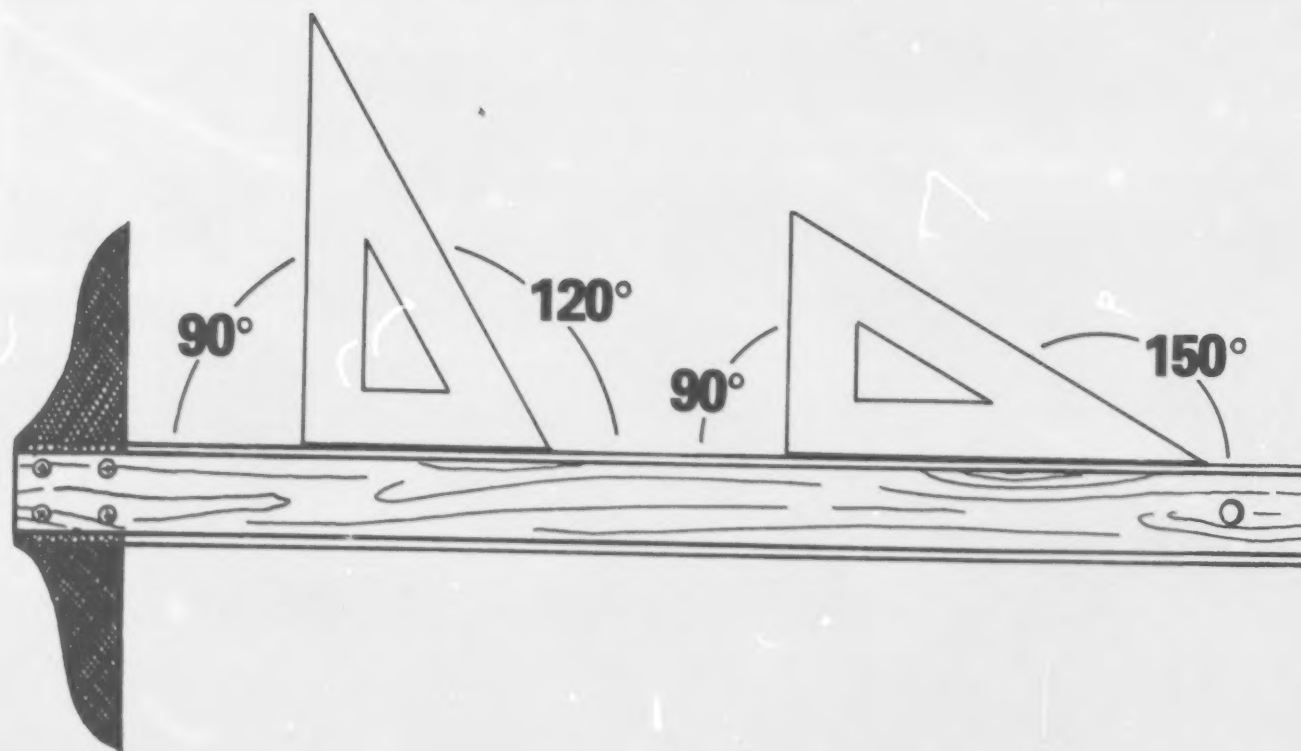
TRIM LINE



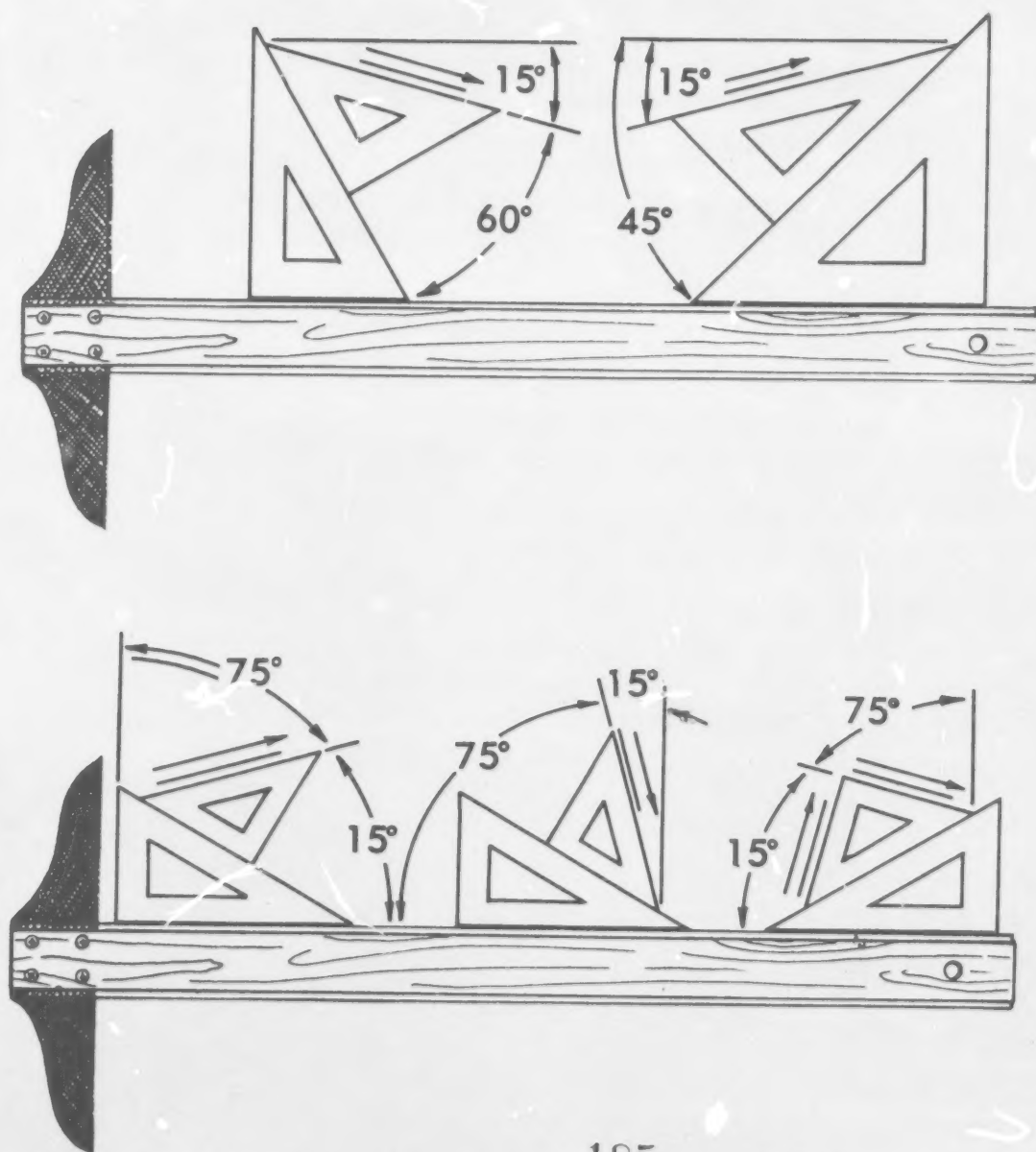
T and 45° Triangle



T and 60° Triangle



T and Both Triangles



UNIT - DRAWING AND PLAN READING

Lesson 3 - How are the letters and numbers drawn on the working plan?

Objective: By the conclusion of the lesson, the student will be able to demonstrate the vertical capital style of lettering.

Study Questions:

1. What steps need to be followed to prepare for lettering?
2. How are the letters made on the plan?
3. How are the numbers made on the plan?

References:

1. Modern Agricultural Mechanics, T.J. Wakeman, The Interstate Printers and Publishers, Danville, Ill.
2. Shopwork on the Farm, Mack M. Jones, McGraw-Hill Book Co.

Transparencies:

1. TM #1: Making Letters
2. TM #2: Making Numbers

Handouts:

1. HO #1: Making Letters
2. HO #2: Making Numbers

UNIT - DRAWING AND PLAN READING

Lesson 3 - How are the letters and numbers drawn on the working plan?

TEACHING PROCEDURE

- A. Review the use of the T-square to make horizontal lines.
- B. Motivation - Show the class an example of a well-labeled drawing.
- C. Assignment
- D. Supervised Study - Have the class trace over examples of lettering using onion-skin or other transparent paper. Check for technique and accuracy.
- E. Discussion

1. Whenever possible use a lettering guide to make the letters on a drawing because of its consistency of height and width. At times this is not possible so it is good to know how to freehand the letters and numbers.

What steps need to be followed to prepare for lettering?

- 1) Using the T-square and a 3H light pencil, draw horizontal boundaries for the letters on the paper.
- 2) The width of the lines will determine the height and width of the letters.
- 3) Practice ahead of time to see if the letters will fit the allocated space.
- 4) If vertical individual letter spacing is preferred, proportion as follows:
 - a) B, C, D, E, F, G, H, J, K, L, N, P, R, S, U, Z slightly narrower width than height space needed
 - b) A, M, O, Q, T, V, X, Y same height and width
 - c) W wider than high by 1/4
 - d) I 1/6 wide as high
- 5) Numbers will be slightly taller than wide
- 6) Creating a square box in which to draw each letter will promote uniformity, for letters 3/8-inch high this would be 3/8-inch by 3/8-inch.

2. The drawing of letters takes considerable practice if done freehand. There is a recommended style presented here which could facilitate the learning of these skills. See HO #1 and TM #1.

How are the letters made on the plan?

- 1) Letter A
 - a) Stroke 1, left side of A downward 60° angle
 - b) Stroke 2, right side of A downward 60° angle
 - c) Stroke 3, horizontal left to right
- 2) Letter B
 - a) Stroke 1, left side of B downward 90° angle
 - b) Stroke 2, bottom of B left to right horizontal
 - c) Stroke 3, center of B left to right horizontal
 - d) Stroke 4, top and upper curve to 3 start top left
 - e) Stroke 5, start from 3 curve to 2 to form bottom of B
- 3) Letter C
 - a) Stroke 1, start from top of the square and form the back of curve, start right to left
 - b) Stroke 2, start from 1 and go left to right
- 4) Letter D
 - a) Stroke 1, downward to form back of D
 - b) Stroke 2, left to right forming bottom of D
 - c) Stroke 3, from top of stroke 1 complete the curve connecting with 2
- 5) Letter E
 - a) Stroke 1, downward to form spine of E
 - b) Stroke 2, left to right forming the base
 - c) Stroke 3, left to right forming the top
 - d) Stroke 4, left to right forming the middle
- 6) Letter F
 - a) Stroke 1, downward
 - b) Stroke 2, left to right top
 - c) Stroke 3, left to right middle
- 7) Letter G
 - a) Stroke 1, top right to left forming the spine (see C)
 - b) Stroke 2, top curve left to right
 - c) Stroke 3, middle left to right connecting with 1 on downstroke
- 8) Letter H
 - a) Stroke 1, form left by downstroke
 - b) Stroke 2, form right by downstroke
 - c) Stroke 3, form horizontal bar left to right
- 9) Letter I
 - a) Stroke 1, downstroke one motion
- 10) Letter J
 - a) Stroke 1, start in right side of box downward to base
 - b) Stroke 2, start left margin curve to meet 1

- 11) Letter K
 - a) Stroke 1, downstroke left side
 - b) Stroke 2, diagonal right to left 60° angle
 - c) Stroke 3, down diagonal from 2 90°-angle to 2
- 12) Letter L
 - a) Stroke 1, downstroke left side
 - b) Stroke 2, left to right base of box
- 13) Letter M
 - a) Stroke 1, downstroke left side
 - b) Stroke 2, downstroke right side
 - c) Stroke 3, diagonal down left to right to center of box
 - d) Stroke 4, diagonal down right to left to center of box
- 14) Letter N
 - a) Stroke 1, downstroke left side
 - b) Stroke 2, downstroke right side
 - c) Stroke 3, diagonal down left top 1 to lower 2
- 15) Letter O
 - a) Stroke 1, make a C, right to left, but use whole box
 - b) Stroke 2, complete O left to right curve, touch right margin
- 16) Letter P
 - a) Stroke 1, downstroke left margin
 - b) Stroke 2, center horizontal leg
 - c) Stroke 3, from top of 1 to 2 curve
- 17) Letter Q
 - a) Stroke 1, same as O
 - b) Stroke 2, same as O
 - c) Stroke 3, add diagonal 30° off perpendicular
- 18) Letter R
 - a) Stroke 1, downstroke left margin
 - b) Stroke 2, center bar left to right horizontal
 - c) Stroke 3, from 1 to 2 as in P
 - d) Stroke 4, add a leg from right part of 2, 30° angle from 90° left to right diagonal
- 19) Letter S
 - a) Stroke 1, top center slight curve right to left
 - b) Stroke 2, down double curve to base
 - c) Stroke 3, left margin to base to 2 right to left
- 20) Letter T
 - a) Stroke 1, full top of box left to right
 - b) Stroke 2, center box downward
- 21) Letter U
 - a) Stroke 1, down left margin
 - b) Stroke 2, down right side
 - c) Stroke 3, slight curve completing base left to right
- 22) Letter V
 - a) Stroke 1, upper left corner to center, base downward at a diagonal
 - b) Stroke 2, upper right corner to center, base downward at a diagonal

- 23) Letter W
 - a) Stroke 1, down 30° angle to base from upper left corner
 - b) Stroke 2, down to base of 1 from upper center
 - c) Stroke 3, down to base at 60° angle to 2
 - d) Stroke 4, down to base from upper right corner meeting 3
- 24) Letter X
 - a) Stroke 1, down from upper left to lower right
 - b) Stroke 2, down from upper right to lower left
- 25) Letter Y
 - a) Stroke 1, upper left to center of box down angle
 - b) Stroke 2, upper right to center of box down angle
 - c) Stroke 3, down at 90° to base from center
- 26) Letter Z
 - a) Stroke 1, left to right top of box centered with slight space on ends
 - b) Stroke 2, down diagonal right of 1 to lower left corner
 - c) Stroke 3, full length of base left to right

3. Numbers are also important to a good plan and need to be made very clearly.

How are the numbers made on the plan?

- 1) Number One
 - a) Stroke 1, downward left margin
- 2) Number Two
 - a) Stroke 1, curve starting at left margin up to top curve to lower left corner
 - b) Stroke 2, horizontal line left to right 3/4 of base
- 3) Number Three
 - a) Stroke 1, start left of center near top; touch top; curve to center
 - b) Stroke 2, start at 1; make reverse C stroke to base
 - c) Stroke 3, from lower left margin curve to stroke 2
- 4) Number Four
 - a) Stroke 1, to the right of center single downstroke
 - b) Stroke 2, from top of 1, diagonal stroke at 60° to left margin
 - c) Stroke 3, from 2 at left margin horizontal nearly to right margin
- 5) Number Five
 - a) Stroke 1, just off left margin from top 1/2 height downstroke
 - b) Stroke 2, from base of 1 upward; then downward curve to base

- c) Stroke 3, from left margin, curve stroke to 2 on base
- d) Stroke 4, top margin from $1 \frac{3}{4}$ of distance to right margin
- 6) Number Six
 - a) Stroke 1, from center of top margin curve to center of left margin; then curve to center of base
 - b) Stroke 2, from center of left margin curve left to right direction to meet 1
 - c) Stroke 3, from start point of 1 curve inward left to right
- 7) Number Seven
 - a) Stroke 1, start upper left corner, horizontal $\frac{3}{4}$ of top length
 - b) Stroke 2, from stop of 1 slight left diagonal to base
- 8) Number Eight
 - a) Stroke 1, from center top line curve to above center of square right to left
 - b) Stroke 2, reverse of 1
 - c) Stroke 3, start from center of square to center of base, right to left
 - d) Stroke 4, reverse of 3
- 9) Number Nine
 - a) Stroke 1, start left of center top margin to touch left margin; then curve across center
 - b) Stroke 2, from start of 1 slow; curve to base
 - c) Stroke 3, from left margin curve to end of 2
- 10) Number Zero
 - a) Stroke 1, start left of center top margin, curve touching left margin to base
 - b) Stroke 2, from start of 1 down to end of one

F. Summary

The lettering used in a working drawing will reflect on the quality of the finished project. Carefully stroke each letter in the prescribed pattern.

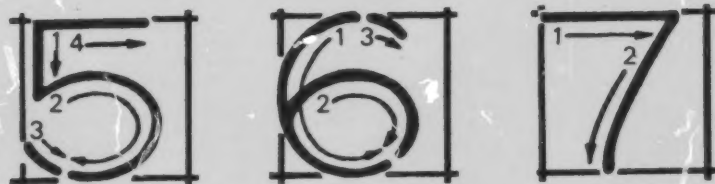
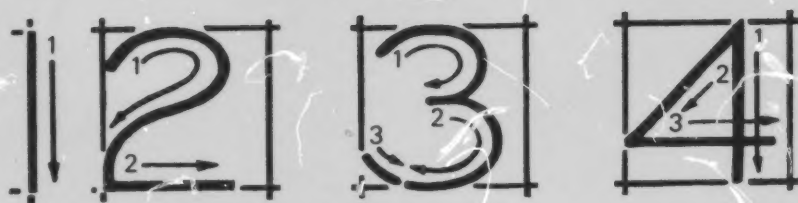
G. Evaluation

Have each student draw a set of the alphabet and numbers to be turned in as a test. Look for consistency and equal size.

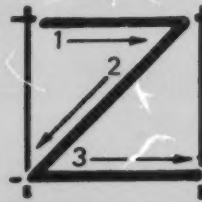
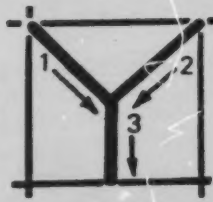
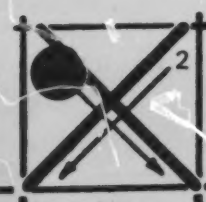
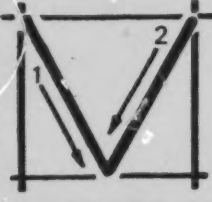
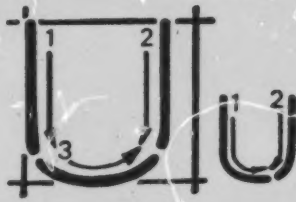
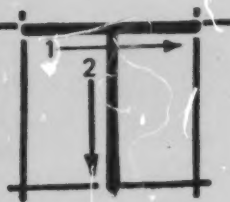
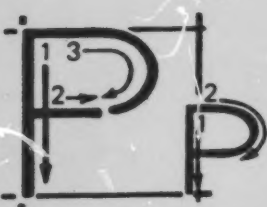
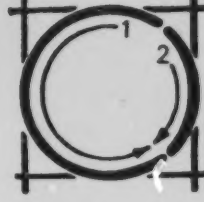
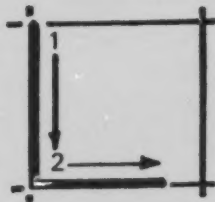
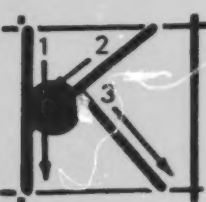
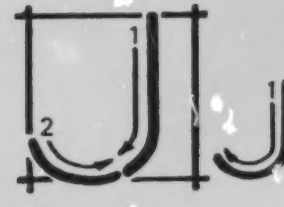
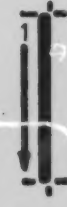
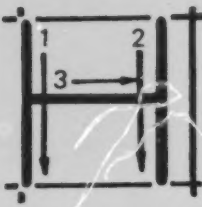
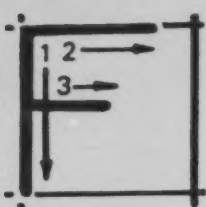
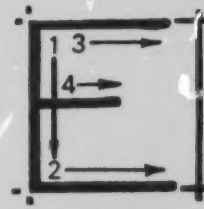
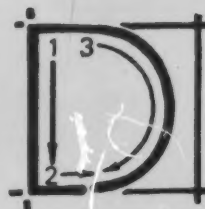
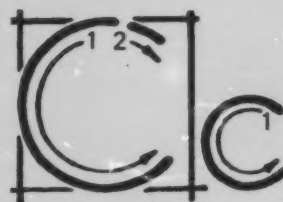
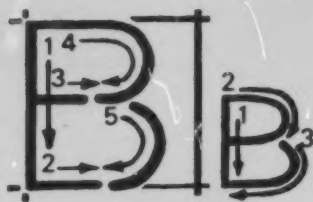
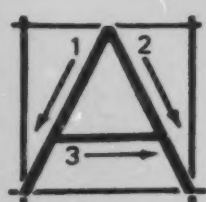
Making Letters



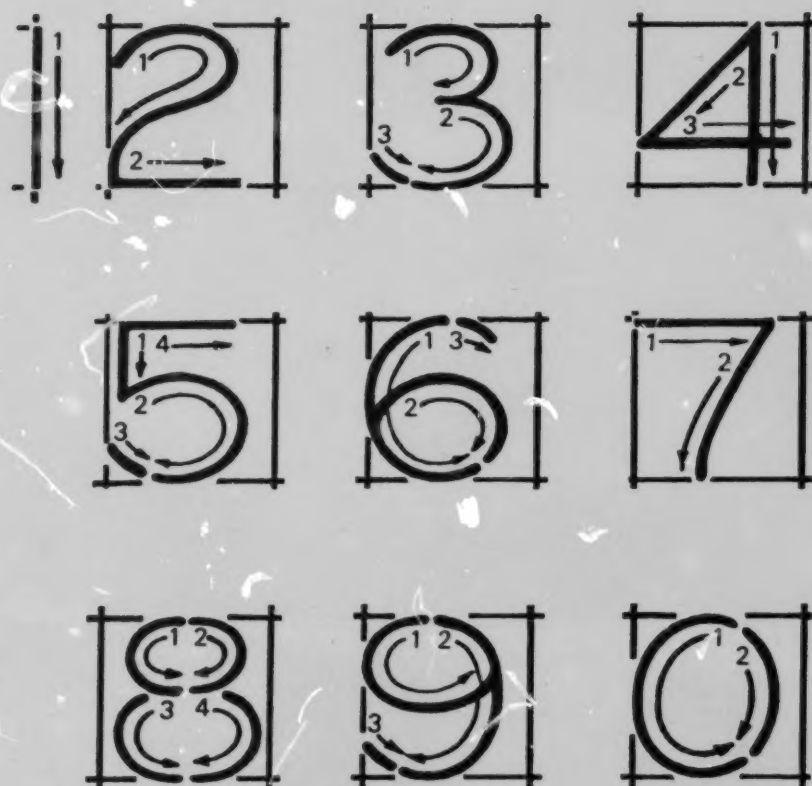
Making Numbers



Making Letters



Making Numbers



195

UNIT - DRAWING AND PLAN READING

Lesson 4 - What are the ways to view a project through working drawings?

Objective: By the conclusion of the lesson, the student will be able to identify and draw isometric, oblique, orthographic, and cross-sectional drawings.

Study Questions:

1. What are isometric drawings and how are they drawn?
2. What are oblique drawings and how are they drawn?
3. What are orthographic drawings and how are they drawn?
4. What are cross-sectional drawings and how are they drawn?

References:

1. Modern Agricultural Mechanics, by T.J. Wakeman. The Interstate Printers and Publishers, Danville, Ill.
2. Shopwork on the Farm, by Mack M. Jones, McGraw-Hill Rural Activities Series.

Transparencies:

1. TM #1: Isometric Drawing
2. TM #2: Oblique Drawing
3. TM #3: Orthographic Drawing
4. TM #4: Cross-sectional Drawing

UNIT - DRAWING AND PLAN READING

Lesson 4 - What are the ways to view a project through working drawings?

TEACHING PROCEDURE

- A. Review setting angles.
- B. Motivation - Show how many different ways a project can be shown. Use examples of a project built in the school that has all the drawings completed on it.
- C. Assignment - Find a plan that has the different views in a magazine or book.
- D. Supervised Study - Have the students verbally describe a plan drawing and the advantages of each view.
- E. Discussion

1. There are four ways to look at an object through drawings: isometric, oblique, orthographic and and cross sectional. Each has its purpose and reasons for being drawn. See TM #1.

What are isometric drawings and how are they drawn?

- 1) Contain three lines or axes
 - a) One vertical
 - b) Two at 30-degree angles with the horizontal
- 2) Drawing shows
 - a) Top view
 - b) A side view
 - c) An end view
- 3) Dimensions of only the main parts can be indicated.

2. Isometric is not the only view considered important to the designer. See TM #2.

What are oblique drawings and how are they drawn?

- 1) Contain three axes
 - a) One horizontal (usually front view)
 - b) One vertical
 - c) Third at any convenient angle
- 2) Same as an ordinary front view
- 3) If any side is irregular that should be the front side

3. The best method of making drawing from which to work is orthographic. These drawings are the most specific of those presented thus far. See TM #3.

What are orthographic drawings and how are they drawn?

- 1) Study the object to be drawn carefully.
 - 2) Select the best views that will describe the object.
 - 3) Three common views
 - a) Front
 - b) Top
 - c) End or side
 - 4) Any one view will usually hide some edges.
 - 5) First drawing step is to make a rough block drawing of the three views.
 - 6) Determine scale on rough drawing and darken in lines and details.
 - 7) Draw in all hidden lines, lettering the dimensions.
4. There will be times when a three-way view will not be enough in working plans. This is especially true when the object is of irregular shape. See TM #4.

What are cross-sectional drawings and how are they drawn?

- 1) Like taking a knife and cutting an object in two sections
- 2) Then removing half and showing the dimensions at the center
- 3) Especially helpful in cases where irregular ends and sides are on an object

F. Summary

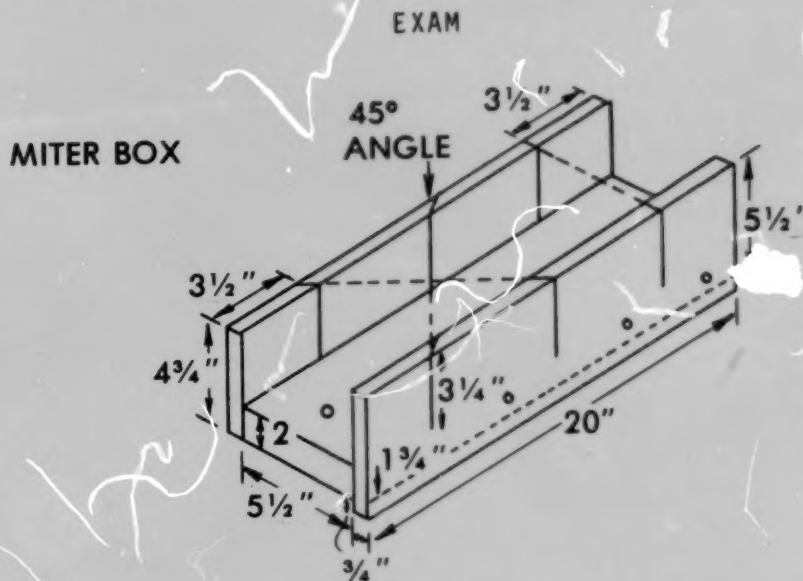
The four views important to mechanical drawing are: isometric, oblique, orthographic, and cross-sectional. Using these views will provide a complete view of any object to be built.

G. Evaluation

Have the students draw three orthographic views of the isometric view of the miter box provided. See Answer Sheet.

UNIT - DRAWING AND PLAN READING

Lesson 4 - What are the ways to view a project through working drawings?



Draw a three view orthographic of the above miter box and label with the following dimensions.

Bill of Material

- 1 - 1" x 5 1/2" x 20" lumber
- 1 - 1" x 4 3/4" x 20" lumber
- 1 - 2" x 6" x 20" lumber
- 8 - 1 1/2" x No. 10 flathead woodscrews

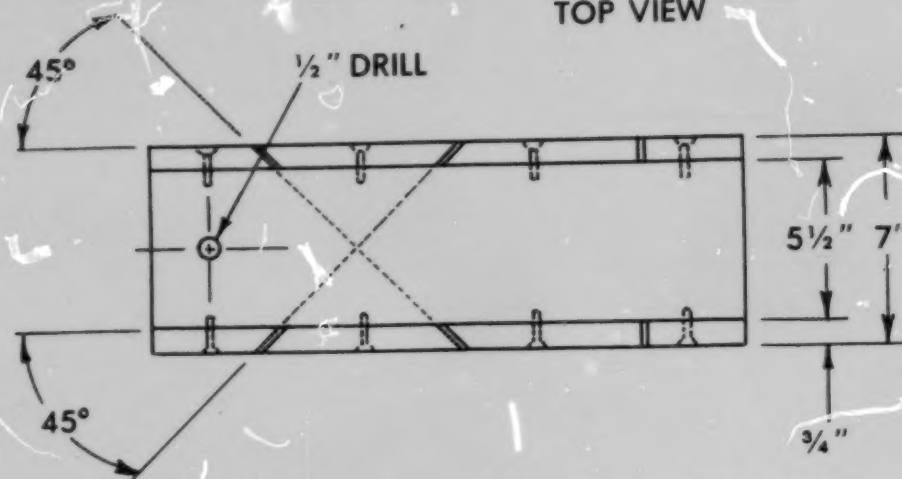
Construction Procedure

1. Mark and cut materials according to the bill of material.
2. Thickness of lumber may be made thinner than shown in drawing.
3. Be sure bottom board is square, otherwise the miter box will not be accurate.
4. Mark and drill holes to receive woodscrews. Be sure to countersink screw heads. Be careful in locating screws so they will not be directly under the saw cuts.
5. Lay out the 45-degree angles very carefully. Cuts may be made with a handsaw, or preferably cut on power saw.
6. Locate and drill hole for hanging or storing the miter box.
7. A suitable finish such as raw linseed oil can be applied if desired.

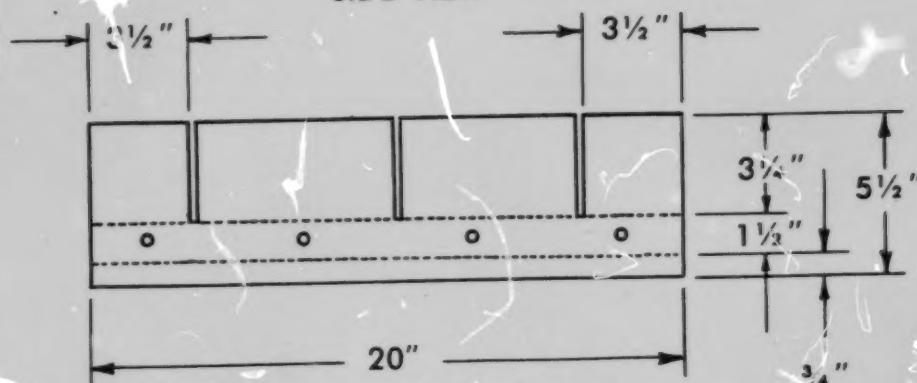
UNIT - DRAWING AND PLAN READING

Lesson 4 - Answer Sheet

TOP VIEW

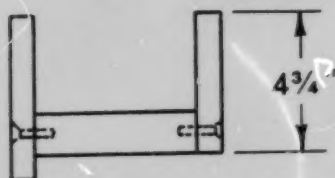


SIDE VIEW

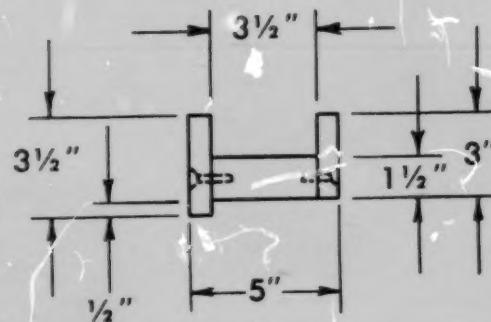


SAME FIGURE ON
TONGUE AND
BLADE TO LAY
OUT 45° ANGLE

END VIEW



ALTERNATE SIZE - END VIEW



MITER BOX

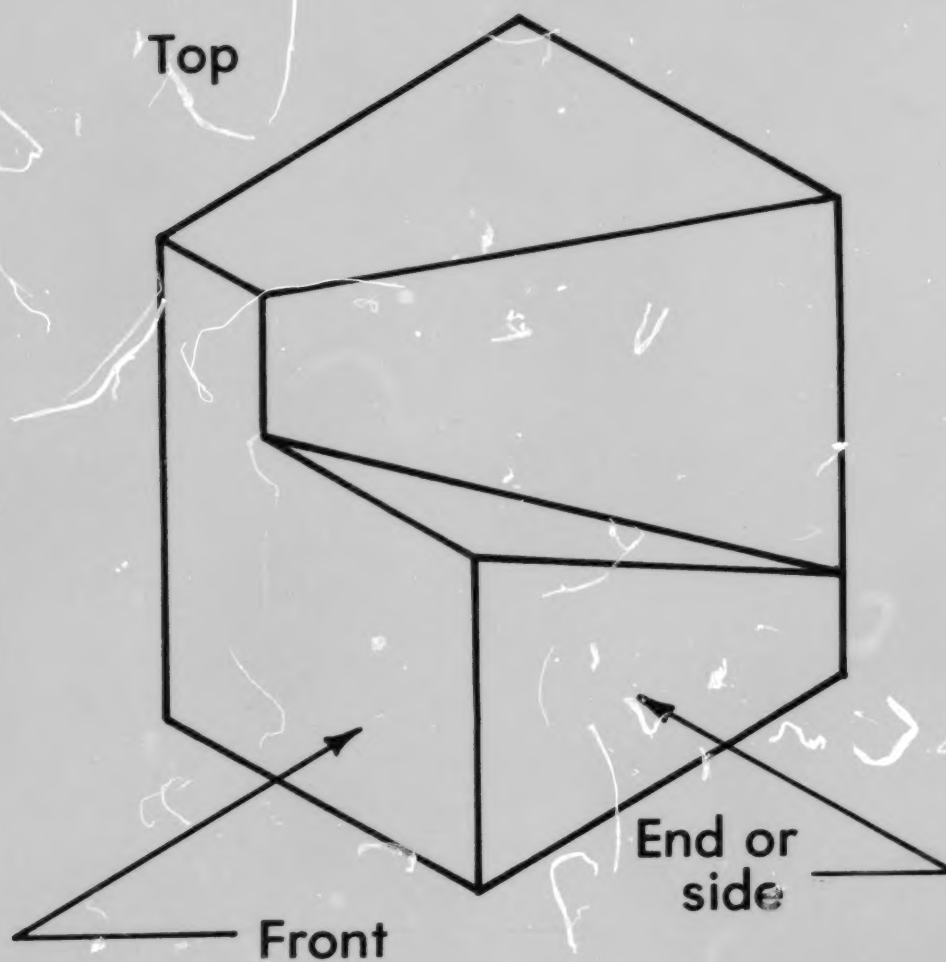
DATE - 24 APRIL 1967

USED - COURTESY - C. WESTON

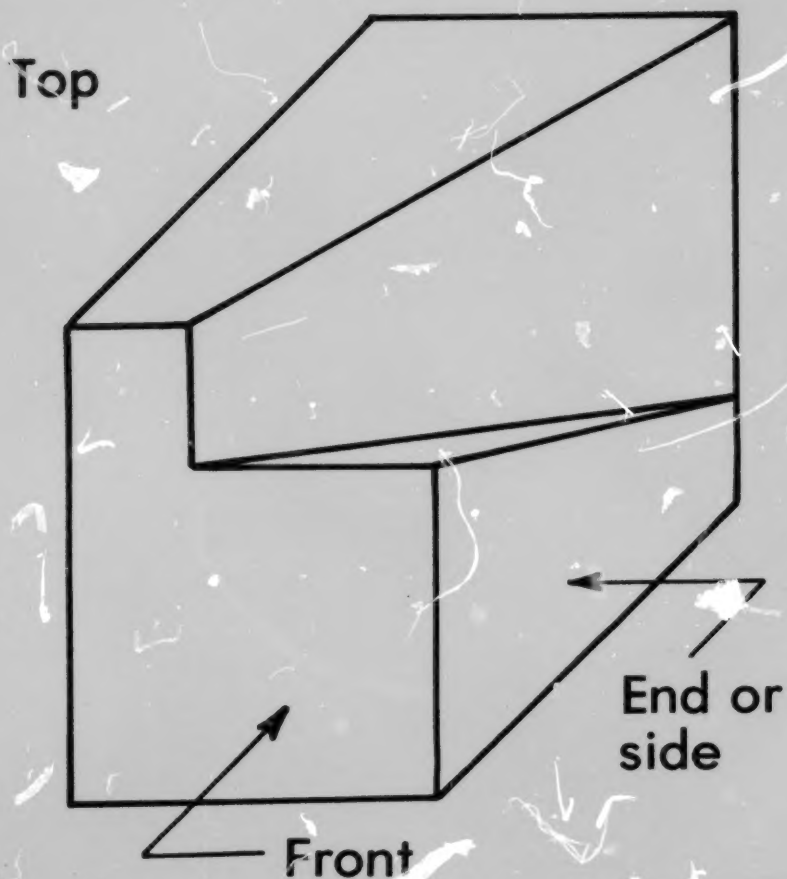
DRAWN & TRACED BY - B. W.

PLAN NUMBER - 854

Isometric Drawing



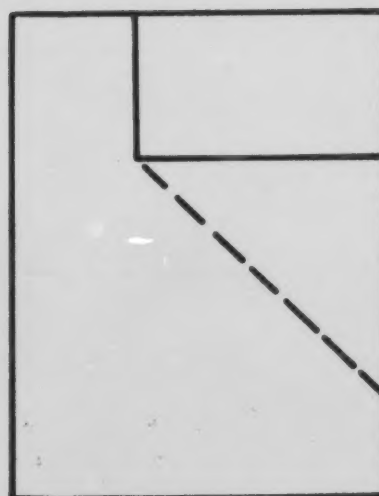
Oblique Drawing



Orthographic Drawing



Top



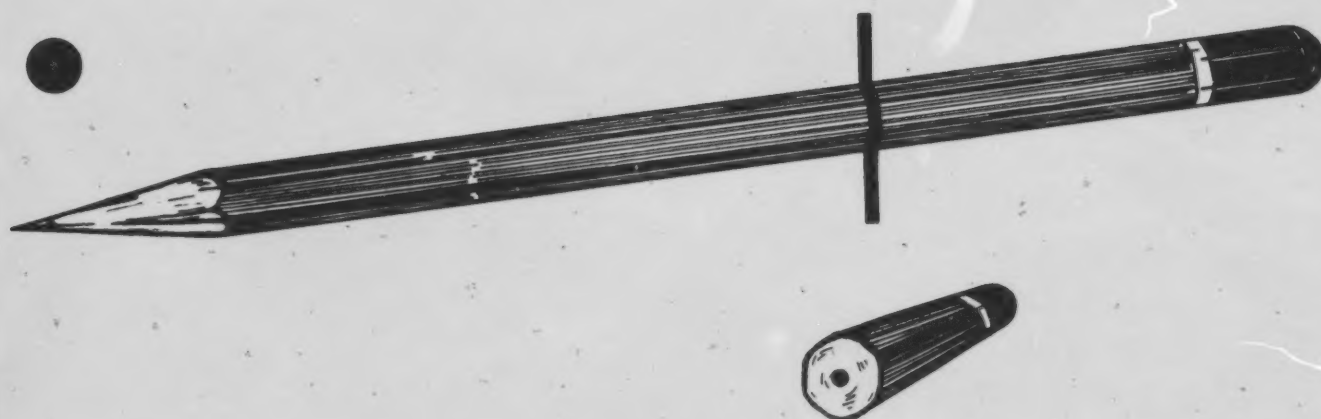
Front



End or side

203

Cross-sectional Drawing



204

UNIT - DRAWING AND PLAN READING

Lesson 5 - What is the correct method for reading a plan?

Objective: By the conclusion of the lesson, the student will be able to read and interpret a working plan.

Study Questions:

1. What is the general procedure for reading a plan?
2. How are dimensions read on a plan?
3. What are the symbols used to indicate different parts of a plan?

References:

1. Blueprint Reading for the Construction Trades, by Herbert Bellis, McGraw-Hill Book Co., New York 1968.
2. Modern Agricultural Mechanics, by T.J. Wakeman. The Interstate Printers and Publishers, Danville, Ill.
3. Planning Project Construction, Hobar Publications Hobar Enterprises Incorporated, 1305 Tiller Lane, St. Paul, Minn. 55112

Transparencies:

1. TM #1: Dimensions
2. TM #2: Building Materials
3. TM #3: Plumbing and Heating Symbols
4. TM #4: Electrical Symbols

UNIT - DRAWING AND PLAN READING

Lesson 5 - What is the correct method for reading a plan?

TEACHING PROCEDURE

- A. Review the types of lines used in drawings.
- B. Motivation - What are all the little symbols on a plan? How can you tell where the plumbing should go? What type of material is used for siding or strength?
- C. Assignment
- D. Supervised Study - In class go over the symbols used on a drawing. Have the class draw each symbol in their notebooks or hand out those provided on the transparencies.
- E. Discussion
 1. Review the meaning of each of the lines in the plan first, then go through this procedure with the class.

What is the general procedure for reading a plan?

- 1)
 - 1) Read title and scale.
 - 2) Glance over plan to gain an overall view.
 - 3) Study the views one at a time to combine in your mind the shape of the object.
 - 4) Check all angles for holes or odd-shaped projections.
 - 5) Put the dimensions into perspective with the scale provided in the title block
 - 6) Check all hidden lines.
 - 7) The three views should show all hidden tapers or angles with the angles well marked.
2. Getting the dimensions straight can be difficult at times, if the drawing is poor. The views provided can complicate matters, so read carefully. See TM #1.

How are dimensions read on a plan?

- 1)
 - 1) First look at the scale of the plan to get an overall idea of the size.
 - 2) Read each dimension to be sure you know the part being described.
 - 3) Check out the drawing thoroughly; study each dimension.
 - 4) Check for duplicate parts, i.e., legs on a sawhorse that will be dimensioned only once.

- 5) Study the transparency noting:
 - a) Dimensioning style
 - b) Angles
 - c) Setting centers
3. There are standard symbols used to denote parts of a project. The larger the project the more symbols, especially when dealing with farm structures.

What are the symbols used to indicate different parts of a plan?

- 1) Architectural symbols - See TM #1.
 - a) Wood
 - b) Concrete, concrete block
 - c) Brick
 - d) Tile
 - e) Insulation
 - f) Metal
 - g) Earth
 - h) Cement floors
 - i) Windows and doors
- 2) Plumbing symbols - See TM #3.
 - a) Shower
 - b) Water closets
 - c) Sink
 - d) Water heater
 - e) Hose connection
 - f) Clean out
 - g) Sump
 - h) Piping symbols
- 3) Heating and ventilation symbols - See TM #3.
 - a) Ventilator
 - b) Fuel oil
 - c) Hot water
 - d) Drain
 - e) Thermostat
 - f) Duct work
- 4) Electrical symbol - See TM #4.
 - a) Outlets
 - b) Switches
 - c) Motor generator
 - d) Lights
 - e) Panels
 - f) Telephone
 - g) Miscellaneous

F. Summary

The key to reading and interpreting a working plan is to proceed carefully and be fully aware of all the dimensions. Careful digestion of the information provided will eliminate simple mistakes.

G. Evaluation

Answers to the Exam

1. a. 1/2-inch x 7 inches x 12 inches
b. 1/2-inch x 7 inches x 7 inches
2. a. Concrete block
b. Earth
c. Door
d. Sink
e. Water heater
f. Thermostat
g. Ceiling outlet
h. Fluorescent light
i. Duplex-convenience outlet
j. Push button

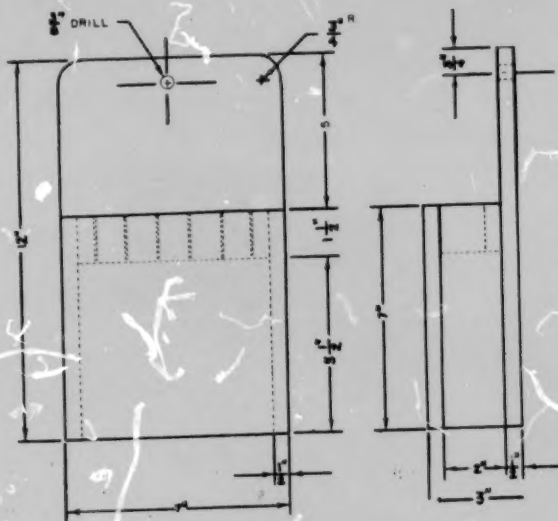
UNIT - DRAWING AND PLAN READING

Lesson 5 - What is the correct method for reading a plan?

EXAM

1. What are the dimensions of the following pieces in the drawing provided?

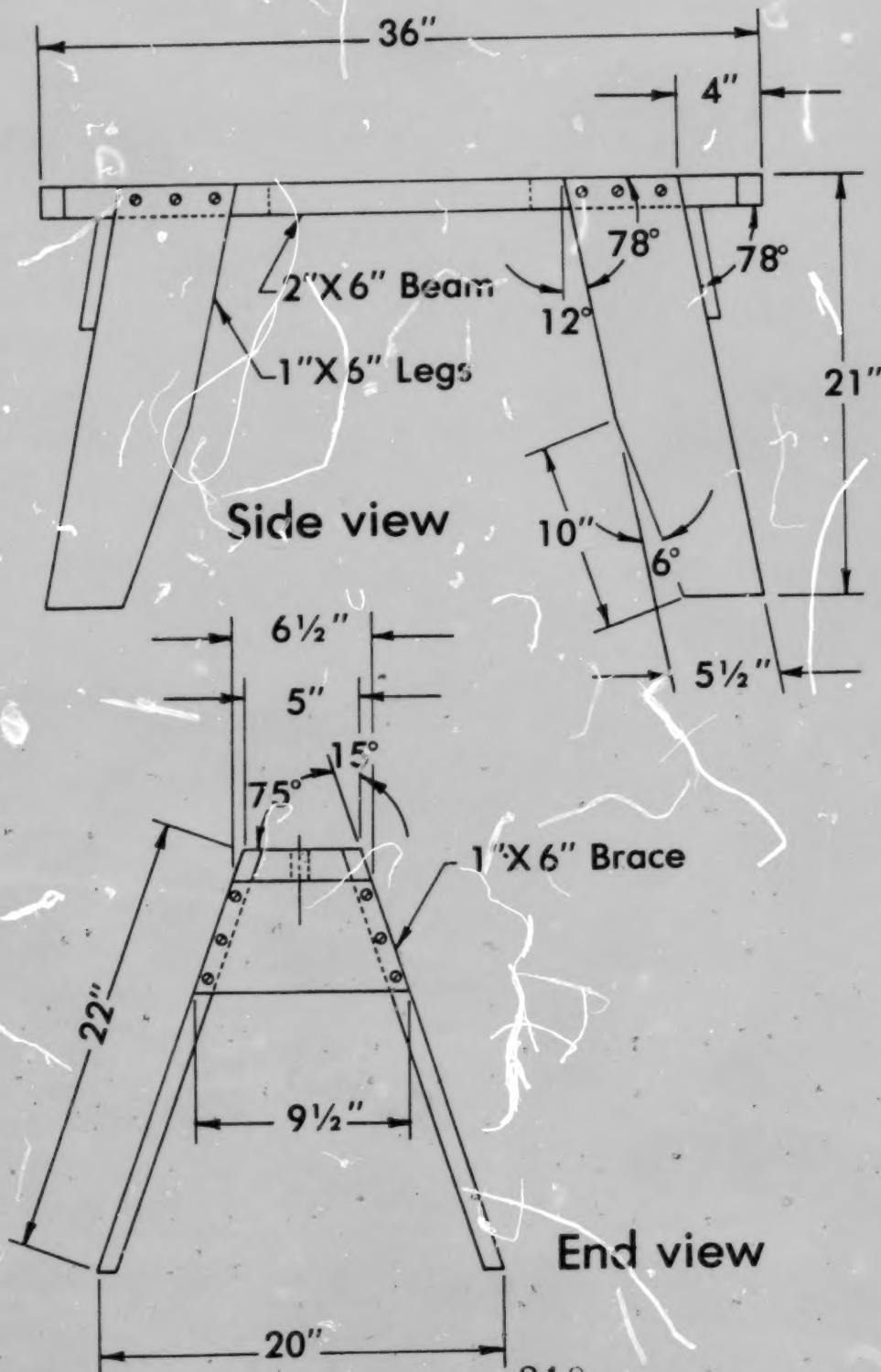
- a. Back piece _____
- b. Front piece _____



2. Identify the following symbols

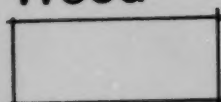
- a.
- b.
- c.
- d.
- e.
- f.
- g.
- h.
- i.
- j.

Dimensions

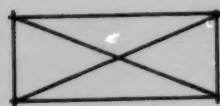


Building Materials

Wood



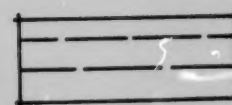
frame studwall



rough

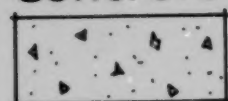


wood



shingle or siding

Concrete



gravel or stone



cinder



concrete block



cinder block



block

Tile



terra cotta



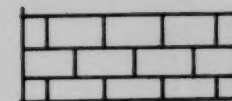
hollow



hollow tile floor arch



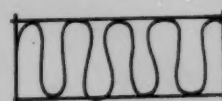
glazed face hollow tile



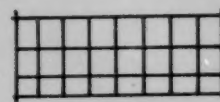
Insulation



rigid



loose or batts

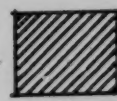


cork

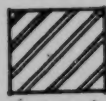
Metal



aluminum

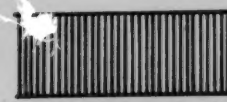


cast iron



steel

sheetmetal & all metals-plan



sheetmetal

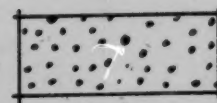
Earth, etc.



earth



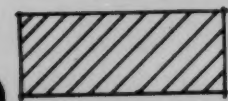
rock



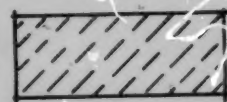
cinders



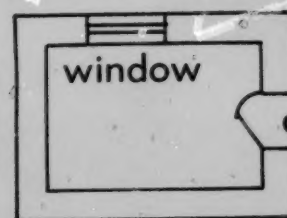
sand



common brick



glass

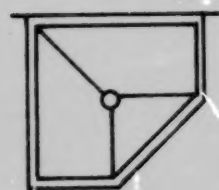


window

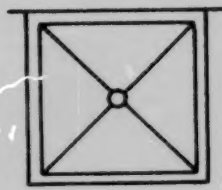
door

● Plumbing and Heating Symbols

Part I Plumbing Symbols

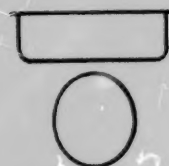
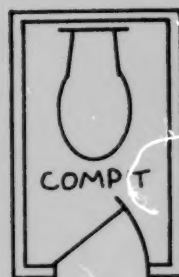


corner

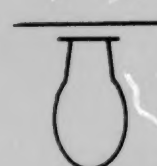


square

Showers

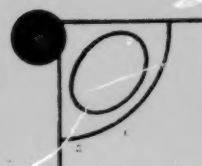


tank



tankless

Water Closets



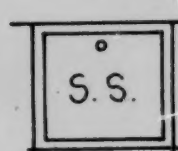
corner



wall



wall

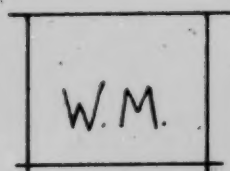


service sink



laundry tray

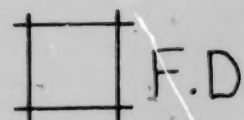
Sinks



washing machine



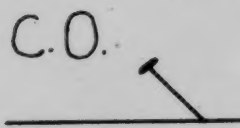
water heater



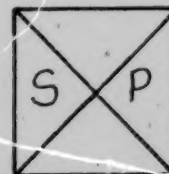
floor drain



hose bib



Cleanout



sump pit

Part II Piping Symbols

soil or waste

above grade

below grade

vent

cold water

hot water

Part III Heating Symbols

fuel oil flow

FOF

fuel oil return

FOR

fuel oil tank vent

FOV

hot water supply

hot water return

supply risers

oUP

oDN

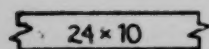
drain

D

thermostat



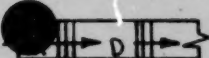
Part IV Duct Work Symbols



duct size

1st fig.-width
2nd fig.-depth

direction of flow



rise or drop in duct

R

register



supply



louver opening

G

grille



exhaust

213

Electrical Symbols

	Ceiling Outlet		Three-Wire Circuit
	Blanked Outlet		Four-Wire Circuit
	Drop Cord		Duplex Conv. Outlet
	Junction Box		Conv. Outlet - 1 Single, 3 Triplex
	Pull Switch - Ceiling		Weatherproof Conv. Outlet
	Exit Light - Ceiling		Range Outlet
	Exit Light - Wall		Switch and Conv. Outlet
	Bracket Outlet		Radio and Conv. Outlet
	Single-Pole - Light Switch		Clock Outlet
	Double-Pole - Light Switch		Special Purpose (See specs.)
	Three-Way - Light Switch		Push Button
	Pilot Light on Light Switch		Buzzer
	Key-Operated Switch		Bell
	Waterproof Switch		Outside Telephone
	Generator		Interconnecting Telephone
	Motor		Exhaust Fan
	Floor Outlet		Air Conditioning
	Fluorescent Light		No. of Circuits to Panel
	Lighting Panel		Conduit - 1 Ceiling
	Power Panel		2 Floor

UNIT - DRAWING AND PLAN READING

Lesson 6 - How is the bill of materials needed in a project determined?

Objective: By the conclusion of the lesson, the student will be able to develop a bill of materials for a project.

Study Questions:

1. What is a bill of material?
2. How is a bill of material compiled?
3. What are some rules of thumb when compiling the bill of materials?

References:

1. Modern Agricultural Mechanics, by T.J. Wakeman. The Interstate Printers and Publishers, Danville, Ill.
2. Planning Project Construction, Hobar Publications, Hobar Enterprises Incorporated, 1305 Tiller Lane, St. Paul, Minn. 55112.
3. Shopwork on the Farm, by Mack M. Jones, McGraw-Hill Rural Activities Series.

Transparencies:

1. TM #1: Plan
2. TM #2: Material List
3. TM #3: Cutting List

UNIT - DRAWING AND PLAN READING

Lesson 6 - How is the bill of materials needed in a project determined?

TEACHING PROCEDURE

- A. Review how to read a plan.
- B. Motivation - Discuss the standard sizes of lumber and all the parts that go into the making of a project. Talk about the cost of waste material.
- C. Assignment - Find a bill of materials at home for a recently completed structure.
- D. Supervised Study
- E. Discussion
 1. Before a project can be built, it is a good idea to draw up a bill of materials. The bill of materials will facilitate the purchasing of materials and reduce the chance of excessive waste.

What is a bill of materials?

- 1) List of amount, size and kind of each item needed
- 2) Need working plan in order to compile list
- 3) Usually a tabular list
- 4) Two types
 - a) Material item list (lumber list) of things to purchase
 - b) Cutting list each item in final cutting form
- 5) If the project is small the two may be combined.
2. There are certain materials that need to be included in the bill of materials. How are they determined?

How is a bill of materials compiled?

- 1) Separate lists for lumber, electrical, plumbing, foundation and metal needs should be made.
- 2) Allow for sufficient planning time.
- 3) Study the plan or sketch.
- 4) Prepare a detailed list of material needs.
- 5) Start with items used first.
- 6) From the list prepare the bill of materials in standard stock sizes.
- 7) Give amounts of each.
- 8) Include everything needed.

3. There are some major points to consider when developing the bill of materials. These points will help to facilitate the development of the bill of materials.

What are some rules of thumb when compiling the bill of materials?

- 1) Plan in standard lengths: 8 ft., 10 ft., 12 ft., 14 ft., 16 ft.
- 2) Allow for waste whether lumber or cement.
- 3) Remember dressed lumber is not full size.
- 4) Note, if tongue-and-groove is used or siding that overlaps.
- 5) Remember how materials are sold: board feet, linear foot, or square foot; order according to need, not cutting measurements.
- 6) Depending on size, the lumber will be compiled by thousand (M) board feet.
- 7) Allow for cutting waste metal or wood.

F. Summary

The bill of materials will facilitate the purchase of materials and cut the amount of waste. Be sure to include all items needed so a bulk purchase, at a lower rate, can be made at the store. It is a good practice to make two lists, material and cutting to make construction easier.

G. Evaluation

Attached is a sawhorse design to be handed out to the class. Have the class draw up:

- a. Materials List
- b. Cutting List

Answer Key

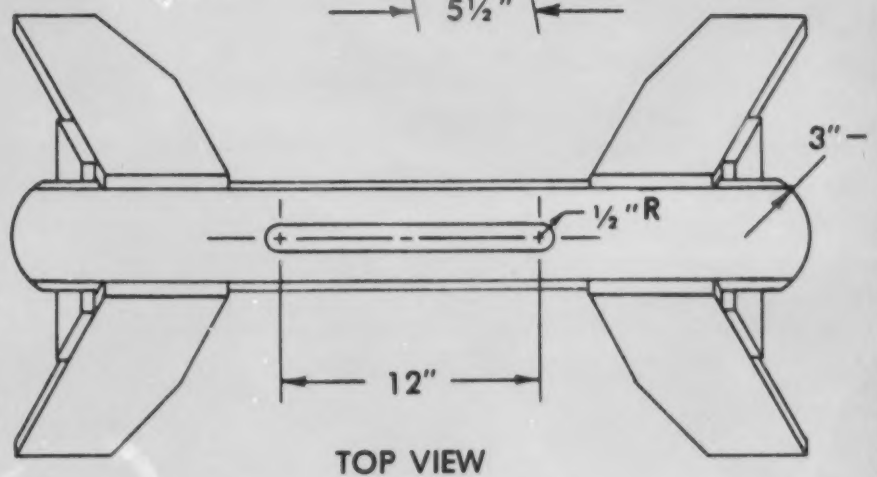
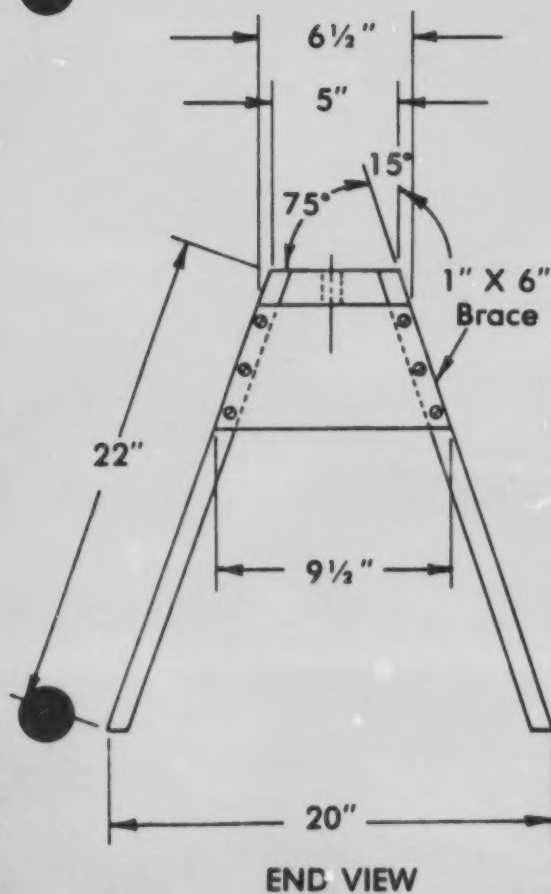
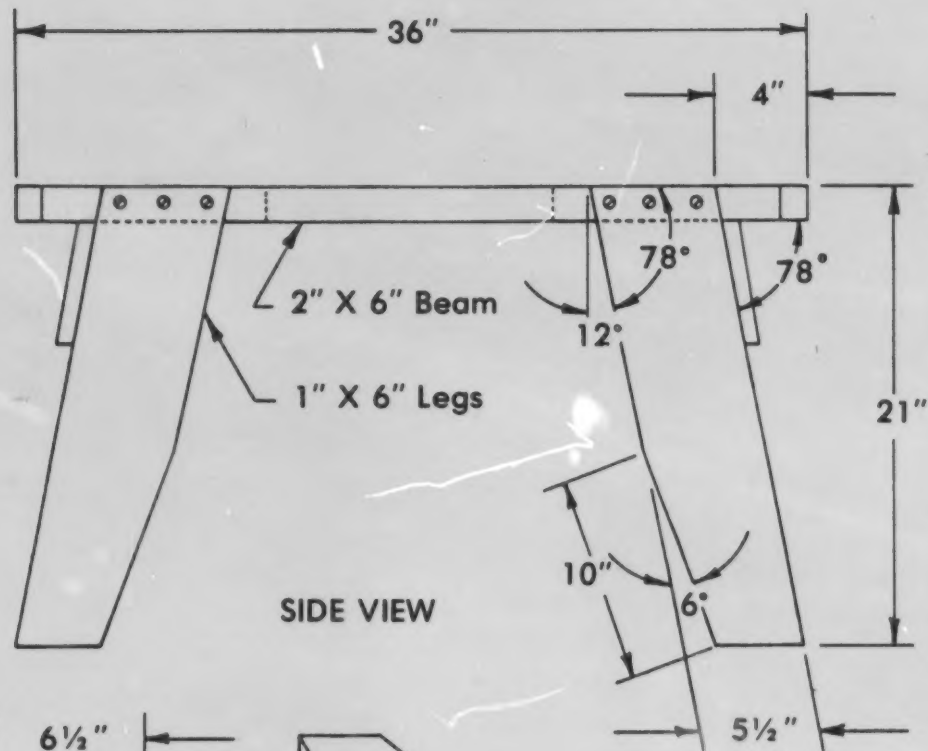
a. Bill of Materials

1-1 inch x 6 inch x 10 feet (5 board ft.)
1-2 inch x 6 inch x 3 feet (3 board ft.)
24-#12 x 1 1/2 inch woodscrews

b. Cutting List

Top
1-2 inch x 5 inch x 3 feet
Legs
4-1 inch x 6 inch x 22 inches
End Boards
2-1 inch x 6 inch x 9 1/2 inches

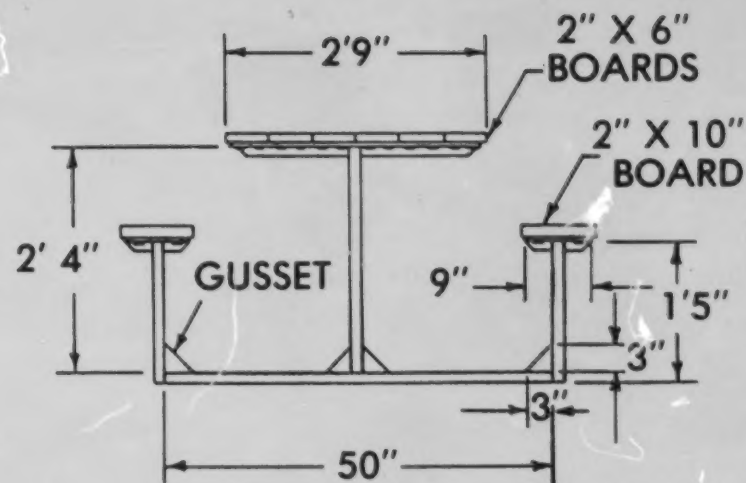
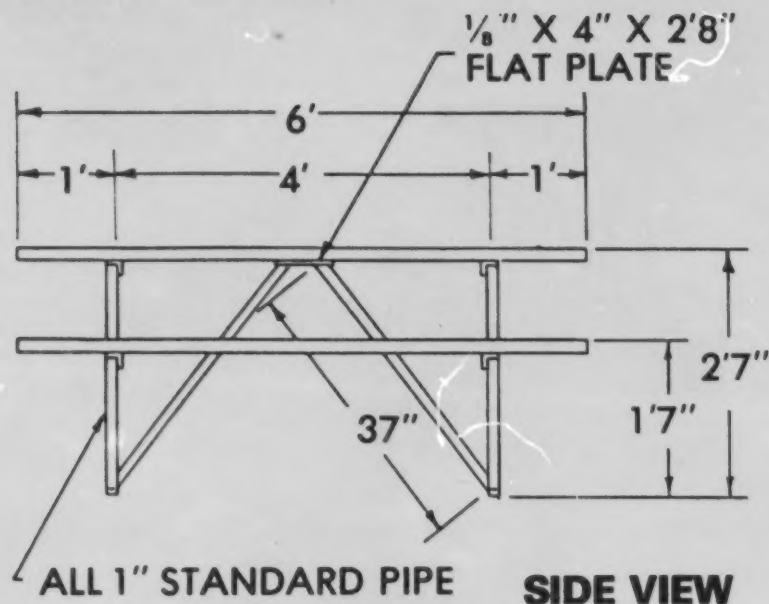
Student Evaluation Saw Horse



218

PLAN

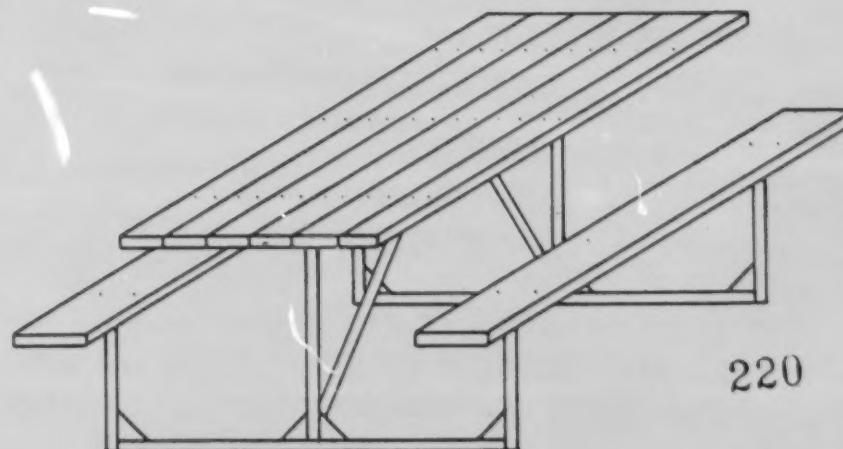
PICNIC TABLE



$\frac{3}{16}$ " X $1\frac{1}{4}$ " X $1\frac{1}{4}$ " ANGLE IRON USED -
ALL ENDS CUT AT 45° ANGLE

SQUARE SETTING ON BRACES
TOP - 5 & 6 OR 51° ANGLE
BOTTOM - $7\frac{1}{2}$ & 6 OR 38° ANGLE

PICNIC TABLE
DATE - 25 MARCH 1967
USED - COURTESY - C. WESTON
DRAWN & TRACED BY - B.W.
Plan PLAN NUMBER - 505



220

Material List

Pipe

1" X 24' 10" black pipe needed

1" X 26' black pipe with waste included

Flat Metal

$\frac{3}{16}$ " X 4" X 32" flat iron

Angle Iron

$\frac{3}{16}$ " X 1 $\frac{1}{4}$ " X 100" angle iron needed

$\frac{3}{16}$ " X 1 $\frac{1}{4}$ " X 105" angle iron with
waste included

Gussets

8- $\frac{3}{16}$ " X 3" X 8" gusset plate needed
precut

Lumber

2" X 10" X 12' (20 board feet)

2" X 6" X 36' (36 board feet)

3 - 12' pieces

Fasteners

Box of 50 - $\frac{1}{4}$ " X 2" carriage bolts

Cutting List

4 - 1" X 17" black pipe

2 - 1" X 50" black pipe

2 - 1" X 28" black pipe

2 - 1" X 37" black pipe

1 - $\frac{3}{16}$ " X 4" X 32" flat iron

4 - $\frac{3}{16}$ " X 1 $\frac{1}{4}$ " X 1 $\frac{1}{4}$ " X 9"
angle iron

2 - $\frac{3}{16}$ " X 1 $\frac{1}{4}$ " X 1 $\frac{1}{4}$ " X 32"
angle iron

8 - $\frac{3}{16}$ " X 3" X 3" gusset plates

2 - 2" X 10" X 72" lumber

6 - 2" X 6" X 72" lumber

DRAWING AND PLAN READING

ASSIGNMENT SHEET #1 (Teacher's Instruction)

Objective: Upon completion of the assignment, the student will be able to make a working drawing of a structure.

Materials Needed:

1. Drawing equipment
2. Listing of symbols
3. Blueprint of your facilities

The objective of this lesson is to have each student complete a working drawing of your school's shop facilities. This work can be checked against the blueprints of the shop or from a set of plans you draw up. Have each student include the following in the drawing and evaluate the student on these components.

1. A top and/or cross sectional view
2. Walls proportional and symbolized as metal, wood, etc.
3. Windows and doors drawn and labeled
4. Electrical and plumbing symbols included
5. All equipment noted
6. Develop a bill of materials (optional)

DRAWING AND PLAN READING

ASSIGNMENT SHEET #2

Objective: Upon completion of the assignment, the student will be able to make orthographic drawings from isometric drawings and complete a bill of materials.

Materials Needed:

1. Drawing equipment
2. Listing of symbols

PART 1: MAKING ORTHOGRAPHIC DRAWINGS

- Step 1: Set up the drawing board.
- Step 2: Check your equipment.
- Step 3: Look at each isometric drawing and complete an orthographic three-view drawing of each.
- Step 4: Check your work for completeness and accuracy before turning it in to the instructor.

PART 2: DEVELOPING A BILL OF MATERIALS

- Step 1: Select one of the drawings (A, D, or F) completed in PART 1 and develop a bill of materials.
- Step 2: Be sure to include:
 - a) Materials list including hardware
 - b) Cutting list
- Step 3: Bill of materials should include:
 - a) Type of material
 - b) Quantity
 - c) Dimensions

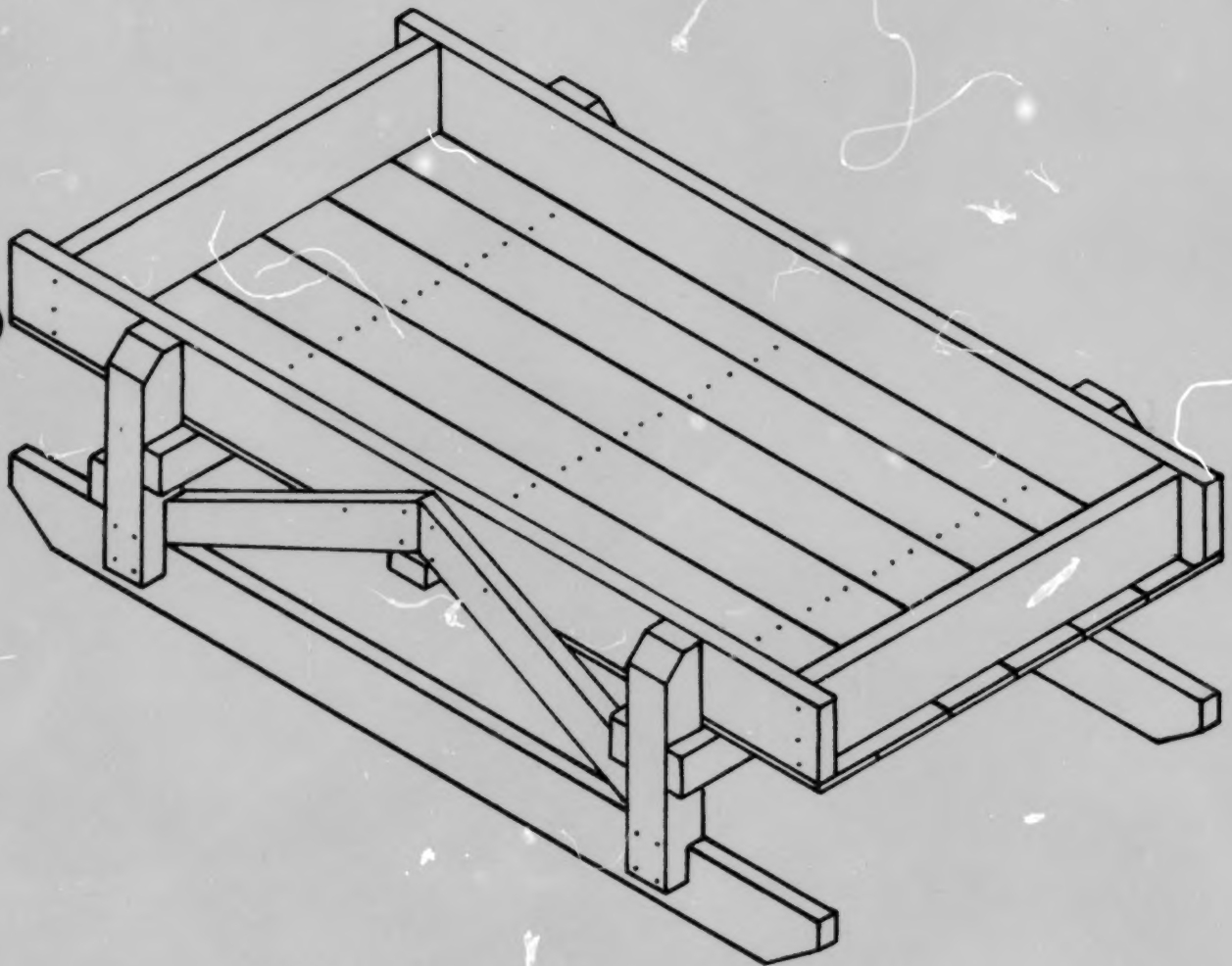
DRAWING AND PLAN READING

ASSIGNMENT SHEET #2 (Teacher's Instruction)

The isometric drawings provided on the following pages are available from IML at the University of Missouri-Columbia as complete drawings with construction instructions. If a plan is appealing to your program, multiple copies are available. Another good source of drawings is the 1960 edition of The Farm Shop by Wakeman and McCoy. A complete listing of the bill of materials is included.

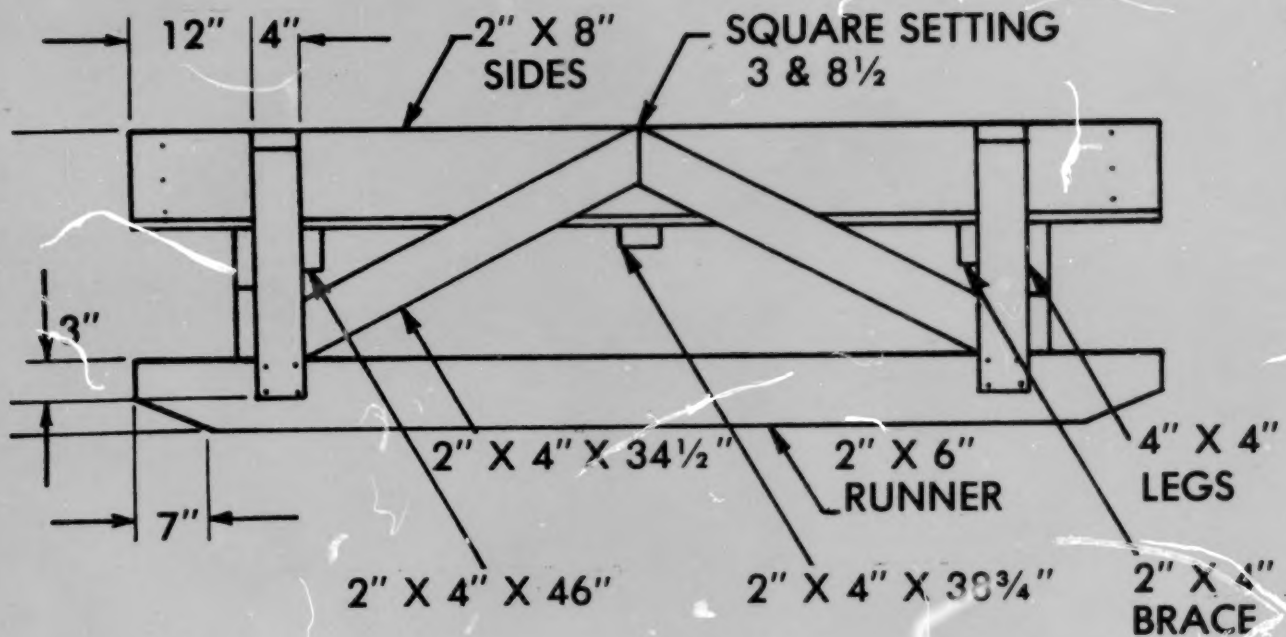
Complete orthographic drawings of the following
isometric view.

A.) CATTLE-FEED TROUGH



226

SIDE VIEW



Bill of Materials

2 - 2" X 6" X 8' RUNNERS

1 - 4" X 4" X 8' LEGS

**3 - 2" X 4" X 8' END BRACES AND
SIDE BRACES**

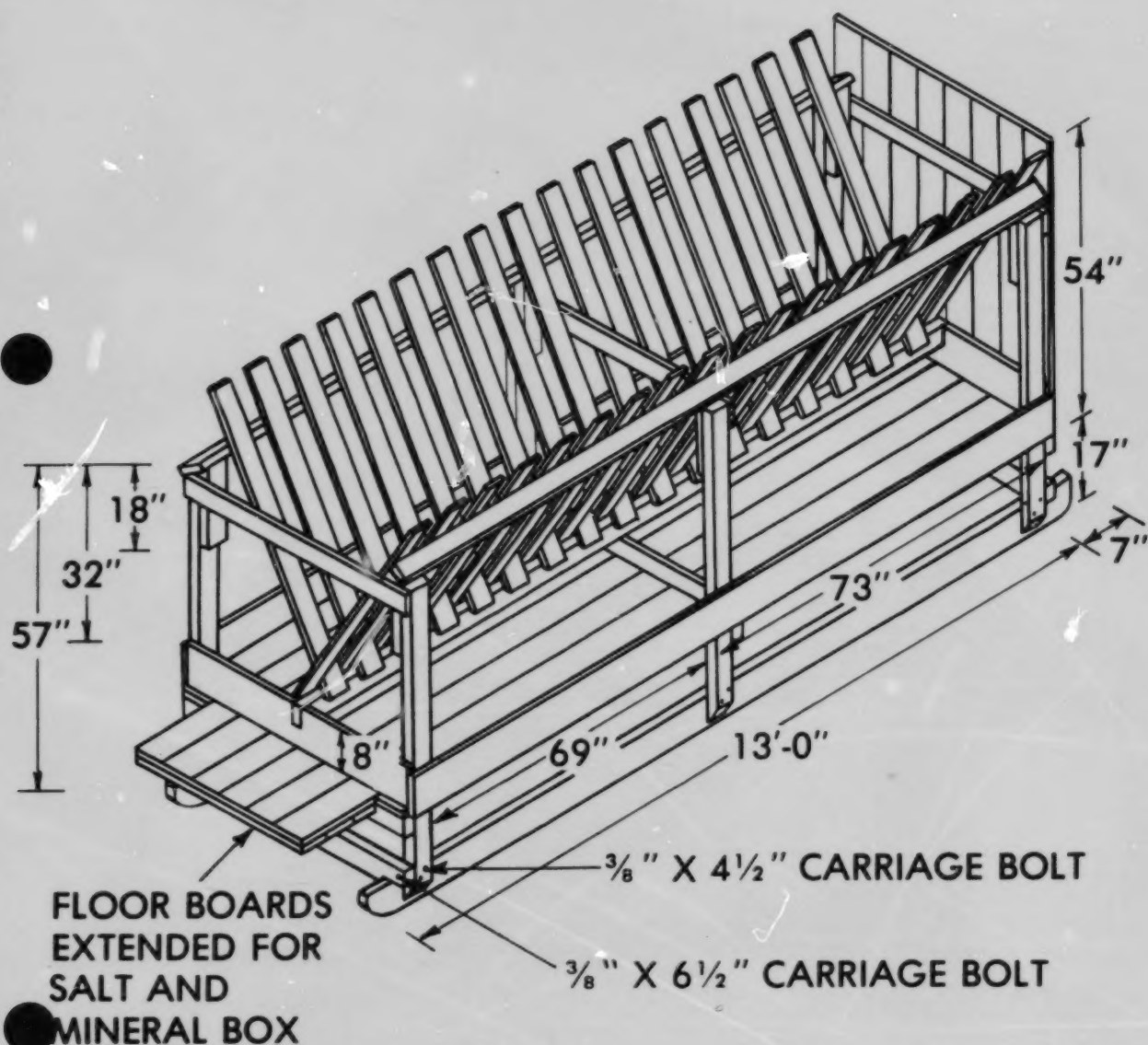
**1 - 2" X 4" X 10' SIDE BRACE AND
CENTER SUPPORT**

3 - 2" X 8" X 8' SIDES AND ENDS

5 - 1" X 8" X 8' FLOOR

Complete orthographic drawings of the following
isometric view.

B.) PORTABLE RANGE FEEDER



228

48" WIDE
1" X 4" X 54" SLATS

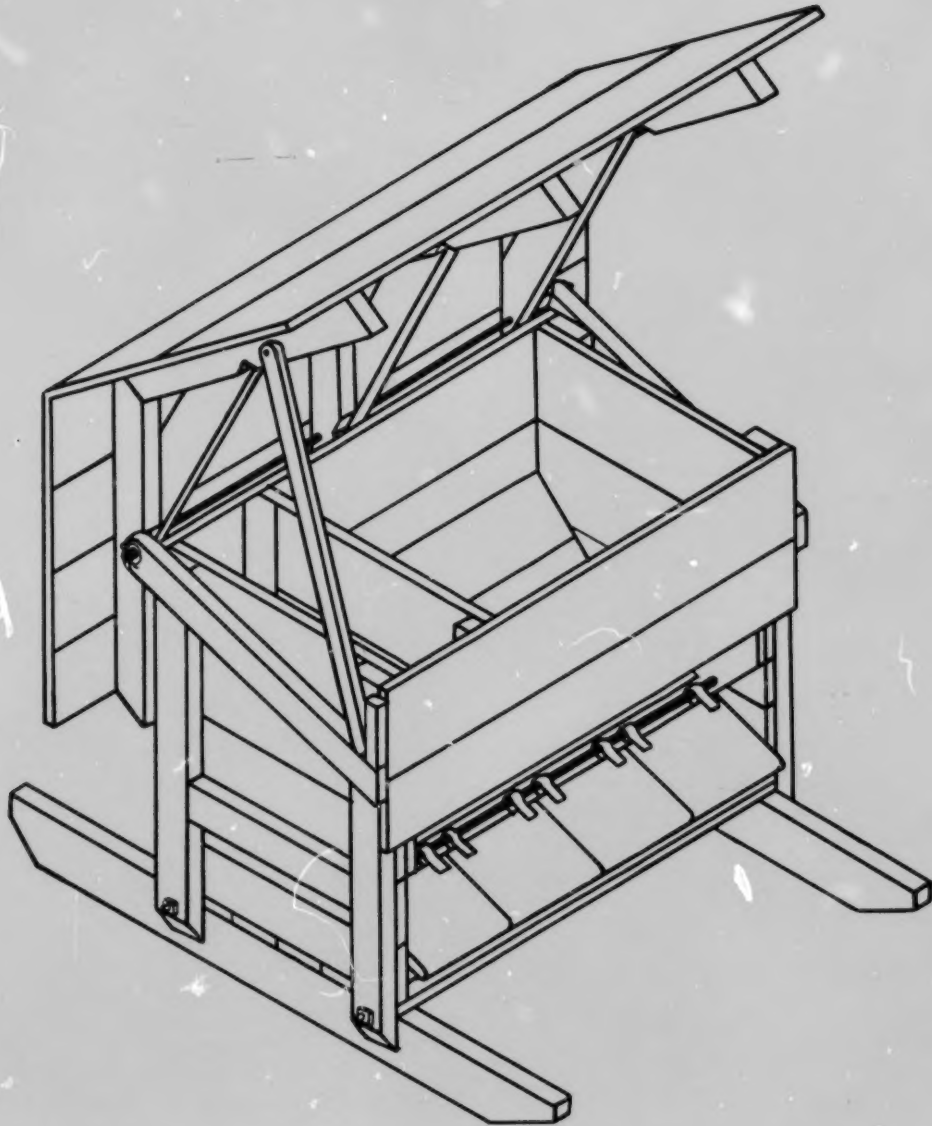
301

BILL OF MATERIALS

Materials Needed	Quantity	Dimensions	Description or Use
Lumber, Unsurfaced			
From cut	2 pieces	2"x 6"x 14'-0"	Runners
	2 pieces	2"x 6"x 13'-0"	
From cut	4 pieces	2"x 4"x 10'-0"	Uprights
	6 pieces	2"x 4"x 60"	
	6 pieces	2"x 4"x 18"	Upright scabs
From cut	5 pieces	2"x 4"x 12'-0"	
	3 pieces	2"x 4"x 48"	Trough supports
	2 pieces	2"x 4"x 48"	
	2 pieces	2"x 4"x 24"	Rafters
and use	2 pieces	2"x 4"x 12'-0"	
	1 piece	2"x 4"x 12'-0"	Top slat supports
From cut	2 pieces	1"x 4"x 8'-0"	
	3 pieces	1"x 4"x 48"	Top crosspieces
	1 piece	1"x 4"x 48"	
	2 pieces	1"x 4"x 6"	Center crosspiece
From cut	15 pieces	1"x 6"x 14'-0"	
	2 pieces	1"x 6"x 12'-2"	Rafter filler block
	6 pieces	1"x 6"x 13'-6"	
	16 pieces	1"x 6"x 54"	Outside floor pieces
	4 pieces	1"x 6"x 38"	
Regular stock	2 pieces	1"x 8"x 12'-0"	Inside floor pieces
From cut	1 piece	1"x 8"x 8'-0"	
	2 pieces	1"x 8"x 48"	End boards
From cut	12 pieces	1"x 4"x 14'-0"	
	35 pieces	1"x 4"x 54"	Sheathing
From cut	1 piece	1"x 8"x 10'-0"	
	2 pieces	1"x 8"x 36"	Trough sides
	1 piece	1"x 8"x 36"	
From cut	3 pieces	1"x 6"x 8'-0"	Trough ends
	6 pieces	1"x 6"x 42"	
			Slats
			Salt-box subfloor
			Salt-box end
			Siding; salt-box partitions
Hardware and Misc.			
Carriage bolts	12	3/8"x 4 1/2"	
	4	3/8"x 6 1/2"	
Washers	32	3/8"	Flat
Common nails	4 lb.	8d	
	2 lb.	20d	
Roofing nails	1/2 lb.	3/4"	
Mineral roofing	1 piece	48"x 36"	Roll roofing
Creosote	2 gal.		
			Preservative

Complete orthographic drawings of the following
isometric view.

C.) SELF-FEEDER FOR HOGS



230

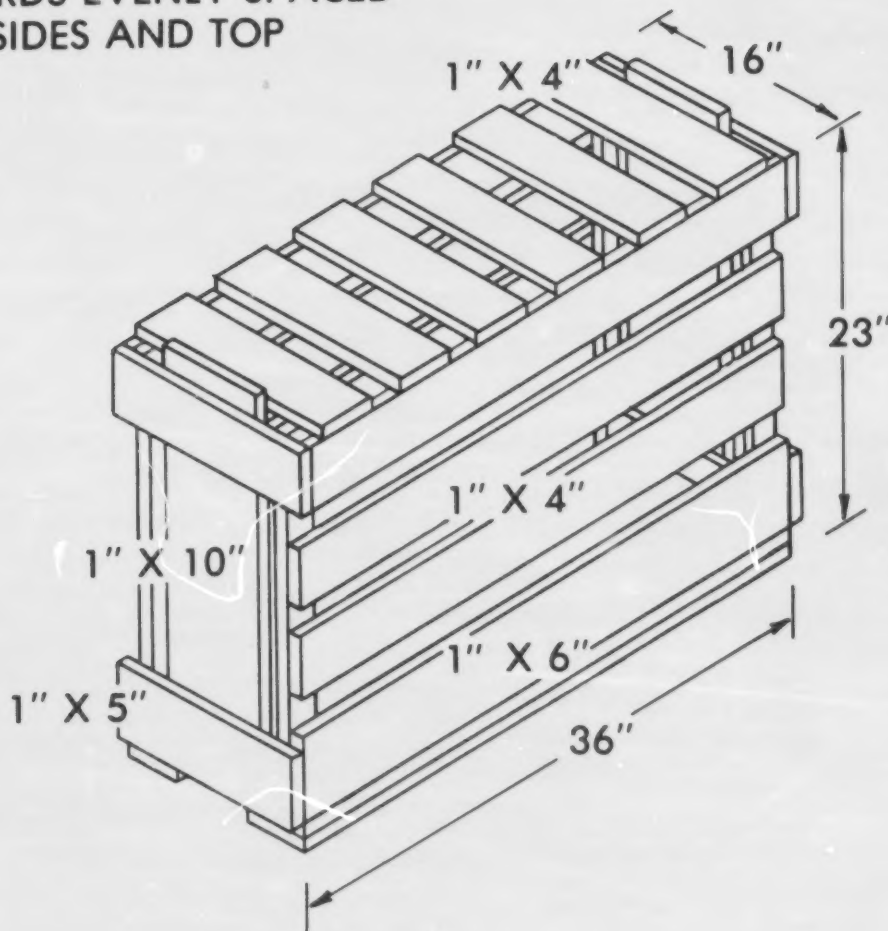
BILL OF MATERIALS

Materials Needed	Quantity	Dimensions	Description or Use
LUMBER			
<i>Unsurfaced</i>	<i>1 piece</i>	<i>2"x 6"x 12'-0"</i>	
Surfaced	2 pieces	1 3/4"x 5 3/4" x 72"	Runners
<i>Unsurfaced</i>	<i>1 piece</i>	<i>2"x 4"x 14'-0"</i>	
Surfaced	4 pieces	1 3/4"x 3 3/4" x 42"	Uprights
<i>Unsurfaced</i>	<i>15 pieces</i>	<i>1"x 6"x 10'-0"</i>	
Surfaced	6 pieces	3/4"x 5 3/4" x 49 1/2"	Floor
	18 pieces	3/4"x 5 3/4" x 30"	Ends
	7 pieces	3/4"x 5 3/4" x 53"	Sides
	7 pieces	3/4"x 5 3/4" x 30"	Partitions
	1 piece	3/4"x 5 3/4" x 30"	Floor batten
	1 piece	3/4"x 5 3/4" x 30"	Center rafter brace
	1 piece	3/4"x 1 3/4" x 48"	Roof prop
	6 pieces	3/4"x 5 3/4" x 48"	Sloped side pieces
		(also use sheathing scrap)	
<i>Unsurfaced</i>	<i>1 piece</i>	<i>2"x 6"x 8'-0"</i>	
Surfaced	2 pieces	1 3/4"x 5 3/4" x 48"	Trough sides
<i>Unsurfaced</i>	<i>2 pieces</i>	<i>1"x 12"x 8'-0"</i>	
Surfaced	2 pieces	3/4"x 11 3/4" x 48"	Feed dividers
	8 pieces	3/4"x 11 7/8" x 12"	Trough lids
<i>Unsurfaced</i>	<i>2 pieces</i>	<i>2"x 6"x 72"</i>	
Surfaced	4 pieces	1 3/4"x 1 3/4" x 14"	Sloped side supports
	4 pieces	1 3/4"x 1 3/4" x 18"	Partition supports
<i>Unsurfaced</i>	<i>2 pieces</i>	<i>2"x 4"x 8'-0"</i>	
Surfaced	2 pieces	1 3/4"x 3 3/4" x 38"	Hinge arms
	2 pieces	1 3/4"x 3 3/4" x 22"	Hinge supports
<i>Unsurfaced</i>	<i>2 pieces</i>	<i>2"x 4"x 10'-0"</i>	
Surfaced	6 pieces	1 3/4"x 3 3/4" x 40"	Rafters
<i>Unsurfaced</i>	<i>6 pieces</i>	<i>1"x 6"x 12'-0"</i>	
Surfaced	12 pieces	3/4"x 5 1/2" x 72"	Sheathing
HARDWARE/MISC.			
From hinge-metal strap cut	1 piece	1/8"x 3/4" x 14'-0"	
Black-iron pipe	16 pieces	1/8"x 3/4" x 10"	Hinges
Washers	2 pieces	1/2" diam. x 55"	Hinge pins
	4	1"	Flat
	22	3/8	Flat
Carriage bolts	16	1/4" x 1 1/2"	
	4	3/8"x 4 1/2"	
	4	3/8"x 5 1/2"	
	2	3/8"x 4 1/2"	
	1	3/8"x 3 1/2"	
Cotter pins	4	1/3" x 1 1/2"	
Box nails	3 lb.	8d	
Common nails	1 lb.	16d	
Roofing nails	1 lb.	3/4"	
Mineral roofing	3 pieces	6'-2" x 36"	Roll roofing

Complete orthographic drawings of the following isometric view and develop a bill of materials.

D.) HOG-SHIPPING CRATE

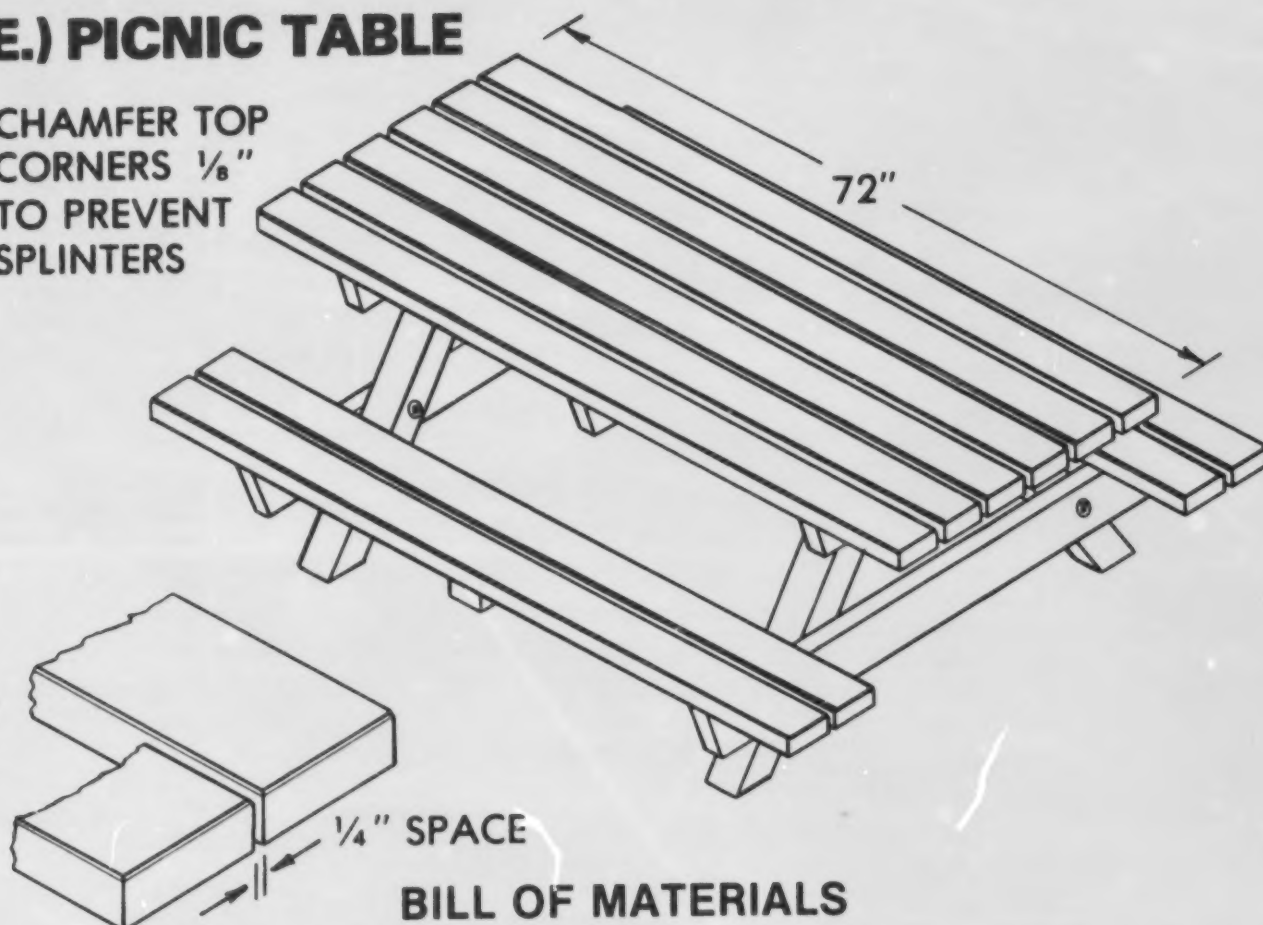
BOARDS EVENLY SPACED
ON SIDES AND TOP



Complete orthographic drawings of the following
isometric view.

E.) PICNIC TABLE

CHAMFER TOP
CORNERS $\frac{1}{8}$ "
TO PREVENT
SPLINTERS



BILL OF MATERIALS

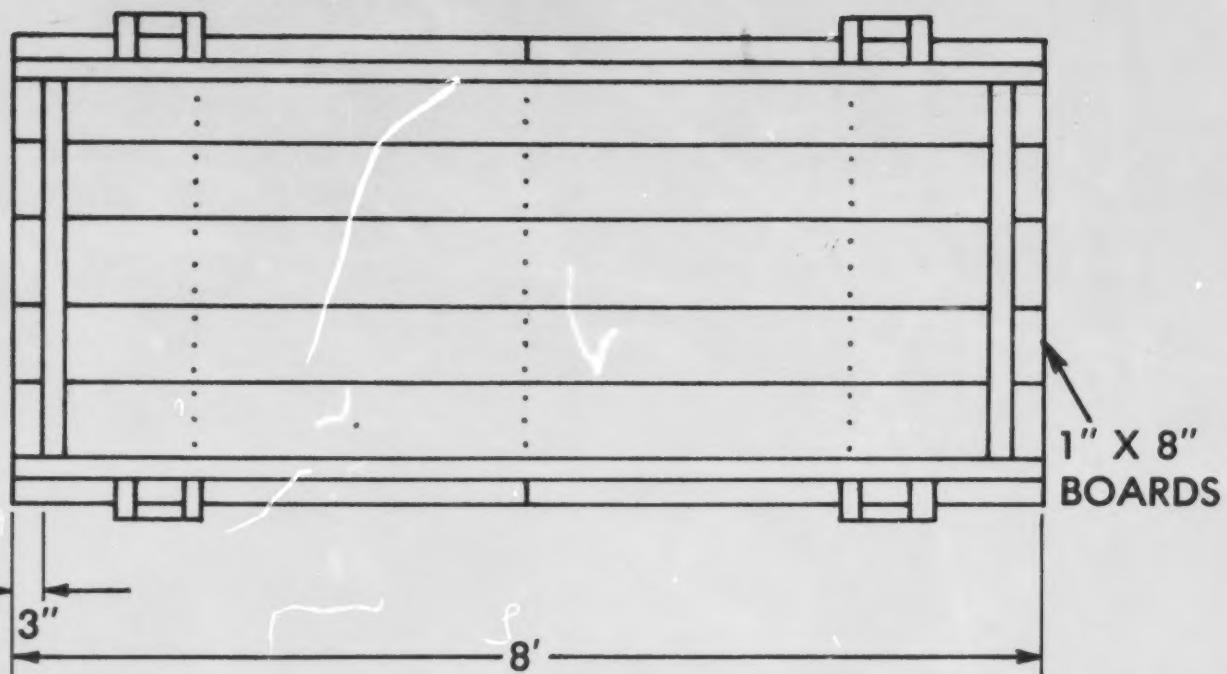
Materials Needed	Quantity	Dimensions	Description or Use
LUMBER			
Unsurfaced	6 pieces	2"x 6"x 12'-0"	Top and seats
Surfaced	10 pieces	1 $\frac{1}{4}$ "x 5 $\frac{3}{4}$ "x 72	
	2 pieces	1 $\frac{1}{4}$ "x 5 $\frac{3}{4}$ "x 66"	
Unsurfaced	1 piece	2"x 4"x 10'-0"	Top supports
Surfaced	3 pieces	1 $\frac{1}{4}$ "x 3 $\frac{3}{4}$ "x 35 $\frac{1}{2}$ "	
Unsurfaced	1 piece	4"x 4"x 12'-0"	
Surfaced	4 pieces	3 $\frac{3}{4}$ "x 3 $\frac{3}{4}$ "x 34"	Legs
Unsurfaced	1 piece	2"x 4"x 8'-0"	
Surfaced	2 pieces	1 $\frac{1}{4}$ "x 3 $\frac{3}{4}$ "x 28"	Braces
	2 pieces	1 $\frac{1}{4}$ "x 3 $\frac{3}{4}$ "x 12"	Seat battens
HARDWARE & FINISH			
Carriage bolts	8	$\frac{1}{2}$ "x 6 $\frac{1}{2}$ "	Flat
Washers	16	$\frac{1}{2}$ "	
Common nails	2 lb.	16d	Outside type
Paint	2 quarts		
Thinner	$\frac{1}{4}$ pint		



Teacher Key

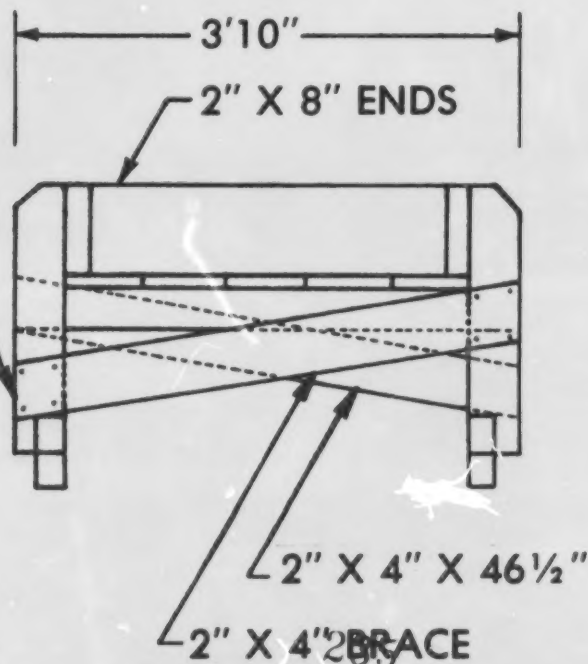
A.) Cattle-Feed Trough

TOP VIEW



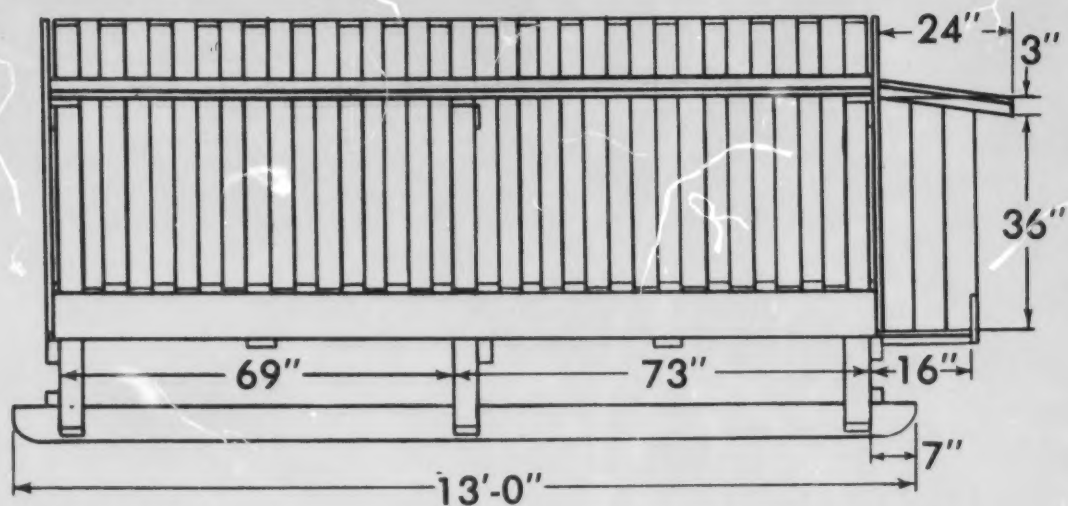
END VIEW

SQUARE SETTING
2 & 14 1/2

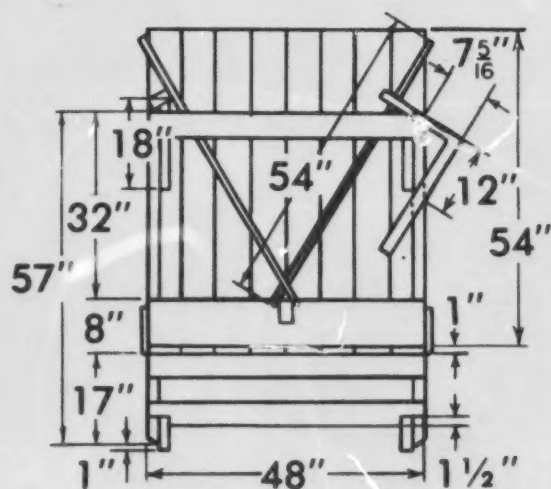


Teacher Key

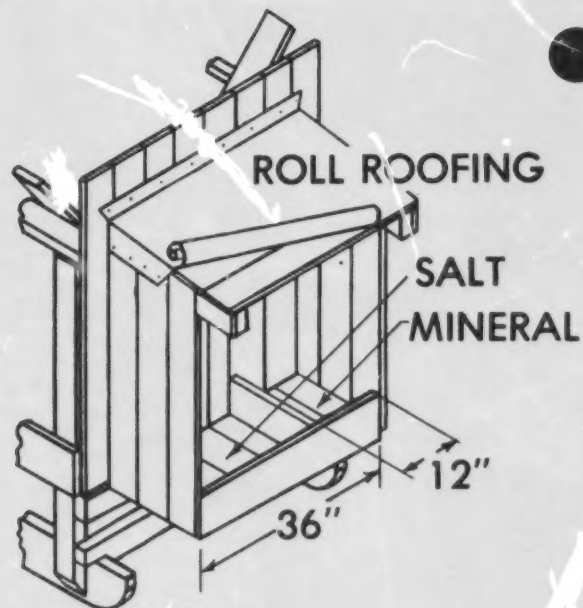
B.) Portable Range Feeder



SIDE VIEW



END VIEW

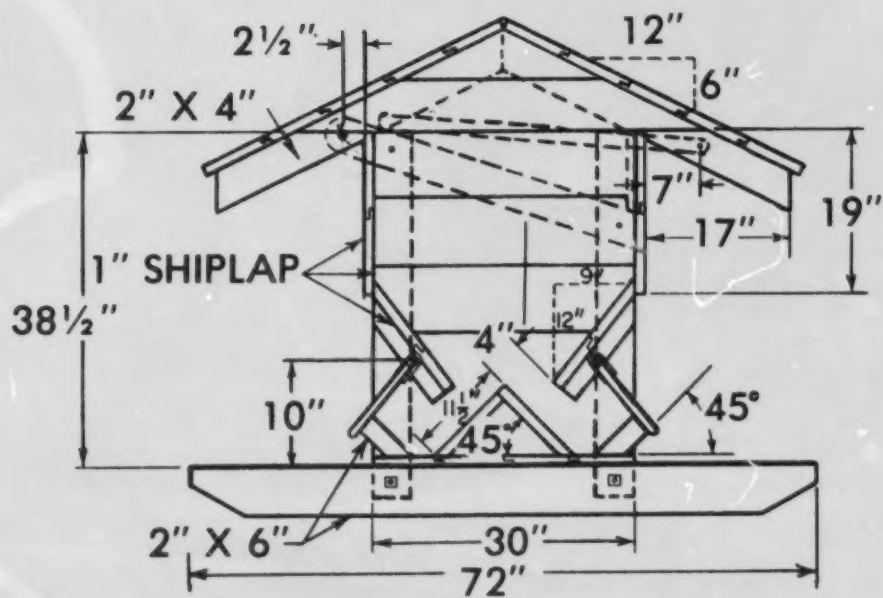
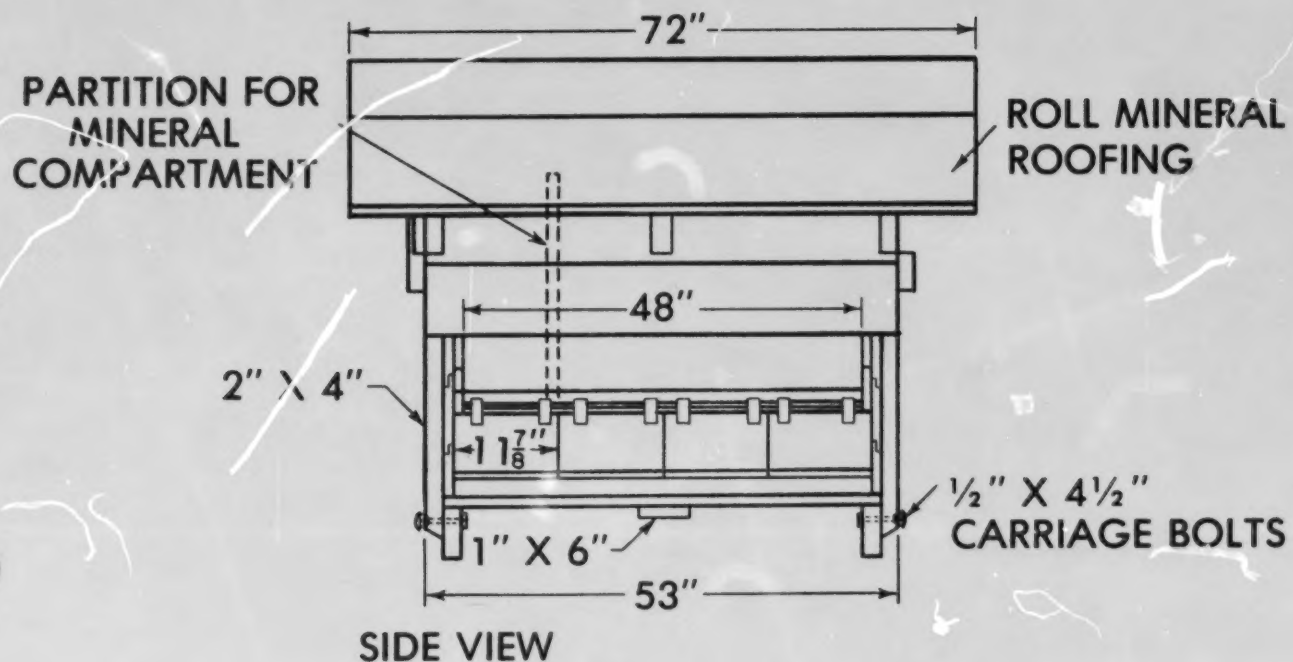


DETAIL OF SALT AND MINERAL BOX

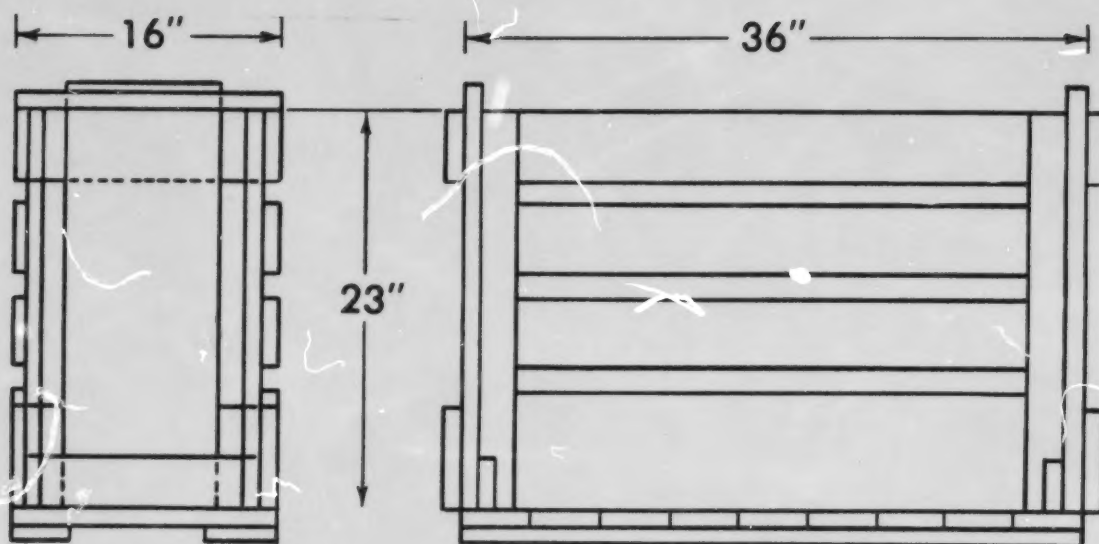
236

Teacher Key

C.) Self-Feeder for Hogs

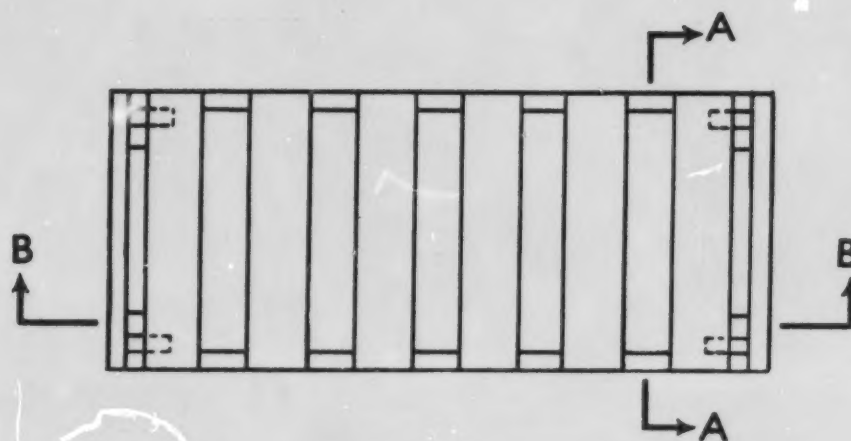


Teacher Key
D.) Hog-Shipping Crate



END VIEW

SIDE VIEW

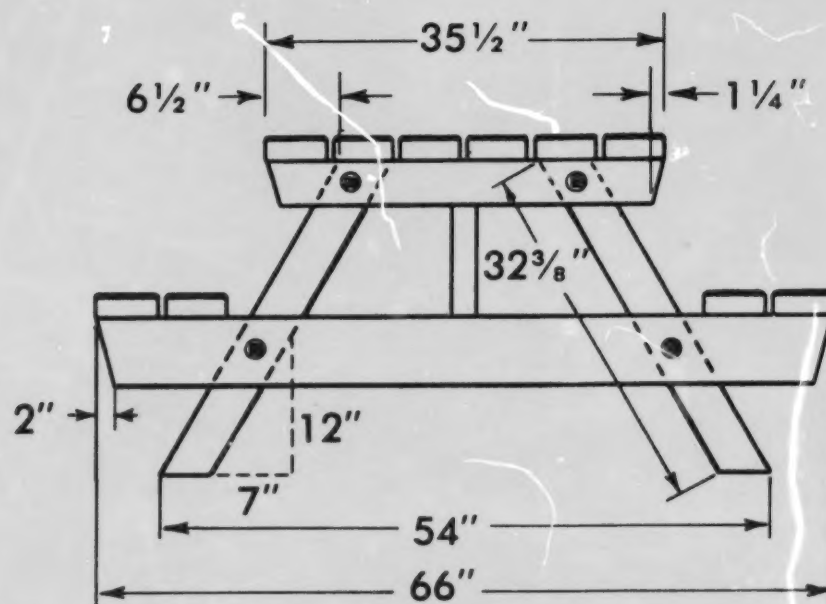
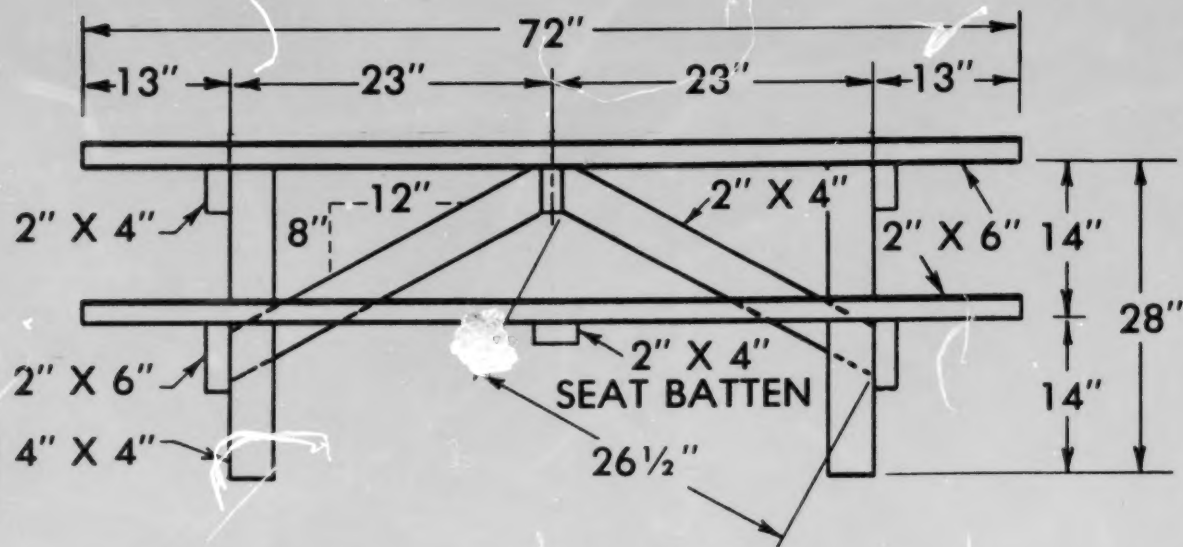


TOP VIEW

BILL OF MATERIALS

Materials Needed	Quantity	Dimensions	Description or Use
Lumber, Unsurfaced			
From cut	1 piece	1"x 6"x 10'-0"	
	2 pieces	1"x 6"x 36"	Bottom side pieces
	2 pieces	1"x 5"x 16"	Bottom end pieces
From cut	7 pieces	1"x 4"x 10'-0"	
	2 pieces	1"x 4"x 36"	Bottom support
	9 pieces	1"x 4"x 16"	Flooring
	4 pieces	1"x 4"x 23"	Corner uprights
	6 pieces	1"x 4"x 36"	Top side pieces
	6 pieces	1"x 4"x 16"	Top crosspieces
	2 pieces	1"x 4"x 12"	Inside doorstep
	2 pieces	1"x 4"x 16"	Top end pieces
From cut	1 piece	1"x 10"x 48"	
	2 pieces	1"x 10"x 24"	Doors
Hardware			
Carriage bolts	2	¼"x 2½"	
Wing nuts	2	¼"	
Box nails	3 lb.	8d	

Teacher Key
E.) Picnic Table

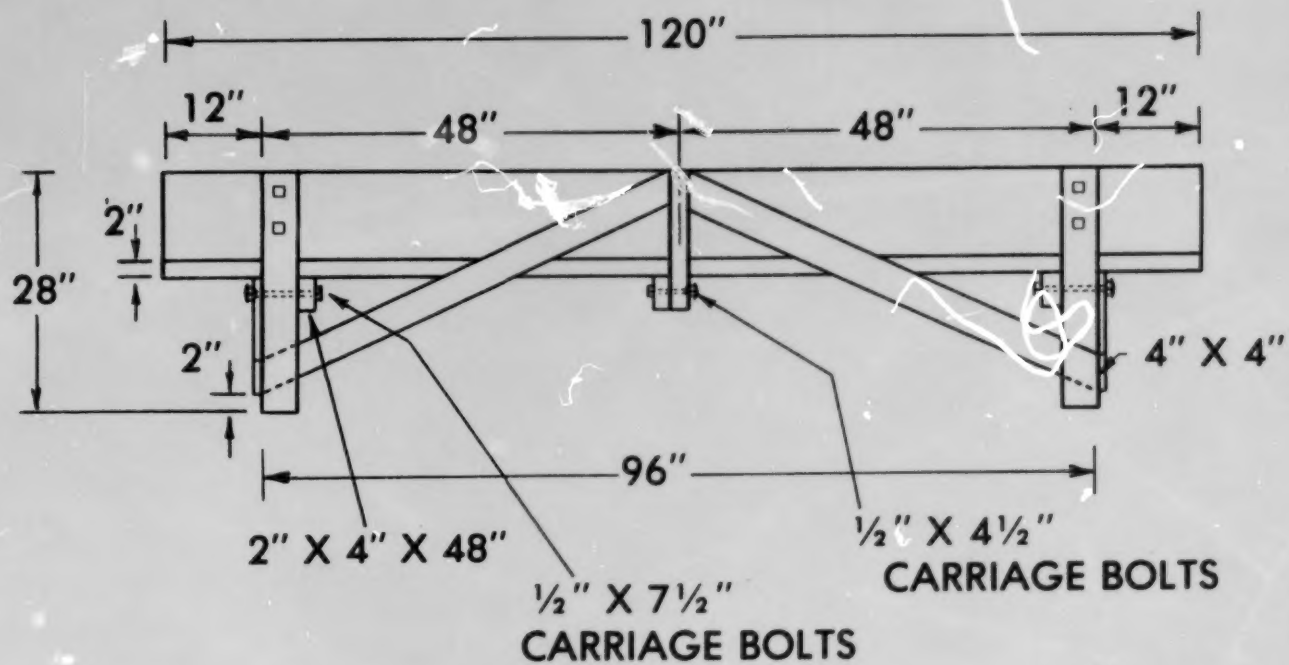


END VIEW 240

Teacher Key

F.) Cattle-Feed Trough

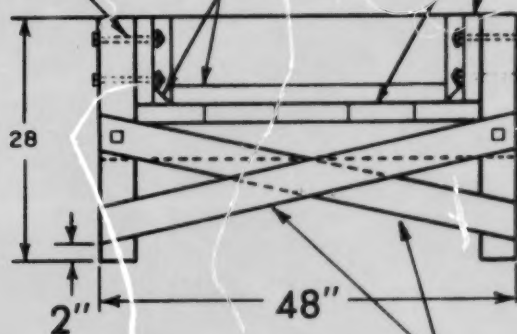
SIDE VIEW



1/2" X 6 1/2"
CARRIAGE
BOLTS

2" X 2"
CHAMFER

2" BOARDS



END VIEW

1" X 4" BOARDS
241

BILL OF MATERIALS

Materials Needed	Quantity	Dimensions	Description or Use
Lumber, Unsurfaced			
From cut	1 piece	4"x 4"x 10'-0"	Legs
	4 pieces	4"x 4"x 28"	
From cut	1 piece	2"x 4"x 12'-0"	End trough supports
	2 pieces	2"x 4"x 48"	Center trough supports
	1 piece	2"x 4"x 44"	
From cut	2 pieces	1"x 4"x 10'-0"	End braces
	4 pieces	1"x 4"x 51"	Trough bottom
Regular stock	4 pieces	2"x 8"x 10'-0"	Trough bottom & sides
	3 pieces	2" x 10"x 10'-0"	
From cut	1 piece	2"x 10"x 8'-0"	Trough ends
	2 pieces	2"x 10"x 36"	
From cut	2 pieces	2"x 4"x 10'-0"	Corner blocks
	4 pieces	2"x 2"x 10"	Center side supports
	2 pieces	2"x 2"x 16"	Chamfer strips
	2 pieces	2"x 2"x 9'-5"	Chamfer strips
	2 pieces	2"x 2"x 33"	
From cut	2 pieces	1"x 4"x 10'-0"	Side braces
	4 pieces	1"x 4"x 54"	
Hardware and Misc.			
Common nails	4 lb.	20d	
	1 lb.	16d	
	1 lb.	8d	
Carriage bolts	8	½"x 6½"	
	4	½"x 7½"	
	6	½"x 4½"	
Washers	36	½"	Flat
Creosote	1 gal.		

UNIT - PLANNING GRAIN-FEED HANDLING

Lesson 1 - Introduction to grain-feed handling structures.

Objective: By the conclusion of the lesson, the student will be able to explain the materials-flow concept and the need for planning.

Study Questions:

1. What is a materials-flow concept?
2. What factors have raised the need for more planning?

Reference:

1. Planning Grain-Feed Handling, MWPS-13, available through Midwest Plan Service, Extension Engineer, University of Missouri-Columbia, Mo. 65211. Cost \$2.50.

Transparency:

1. TM #1: Prior Planning

UNIT - PLANNING GRAIN-FEED HANDLING

Lesson 1 - Introduction to grain-feed handling structures.

TEACHING PROCEDURE

A. Review

- B. Motivation - How do you plan for grain facilities?
What factors will need to be considered
when planning the facility?

C. Assignment

D. Supervised Study

E. Discussion

1. In order to properly plan a facility, the designer needs to understand the concept of how to move the materials from point to point.

What is a materials-flow concept?

- 1) Control the volume of crops produced and live-stock fed.
 - 2) Consider these factors in the flow:
 - a) Timeliness
 - b) Capacity to get job done
 - c) Quality control
 - d) Dependability of purchased services
 - 3) As volume increases so does mechanization.
 - 4) Best key to organized farm mechanization is materials-flow concept.
 - 5) The flow provides a means of integrating field machinery and farmstead equipment and structures. It also gives a direction for growth and expansion.
 - 6) The use of portable conveyors, which was once best but now outdated, was good when:
 - a) Volumes were small.
 - b) Harvests were low.
 - c) Transport rates were low.
 - d) Lots of labor was available
 - 7) Today, the need is for ready-to-go equipment systems linked together to function as a unit.
2. The saying, "Prior planning prevents poor performance" is applicable to grain-feed handling facilities. There is a serious need in expandable operations to plan for the future. Use TM #1.

What factors have raised the need for more planning?

**Prior
Planning
Prevents
Poor
Performance**

UNIT - PLANNING GRAIN-FEED HANDLING

Lesson 2 - What is a closed-loop handling system?

Objective: By the conclusion of the lesson, the student will be able to set up and expand a closed-loop grain handling system.

Study Questions:

1. What are the components of a closed-loop handling system?
2. What are some options in a small simple-loop system?
3. When expanding to a large capacity closed-loop system, what factors need consideration?
4. What are some conveyor options in a closed-loop system?

Reference:

1. Planning Grain-Feed Handling, MWPS-13, available through Midwest Plan Service, Extension Engineer, University of Missouri-Columbia, Mo. 65211. Cost \$2.50.

Transparencies:

1. TM #1: Components of Grain System
2. TM #2: Options for Grain Systems
3. TM #3: Use of Horizontal Conveyors
4. TM #4: Hopper Use
5. TM #5: Inclined Conveyor

UNIT - PLANNING GRAIN-FEED HANDLING

Lesson 2 - What is a closed-loop handling system?

TEACHING PROCEDURE

- A. Review the need for preplanning in a farming operation.
- B. Motivation - How many of you have grain handling facilities on your home farm? Can you unload quickly, handle wet grain, and work in all types of weather?
- C. Assignment - Make a sketch of your home grain handling system or sketch a system in your area. Include bins, movers, dryers, etc.
- D. Supervised Study
- E. Discussion

1. The ideal grain-flow design develops a closed-loop handling system through each storage and process element. What equipment is needed to complete the loop? See TM #1.

What are the components of a closed-loop handling system?

- 1) Bin
- 2) Dryer
- 3) Bin-dryer combination
- 4) Grain dump (drive-over preferred)
- 5) Conveyor to a vertical elevator
- 6) Vertical elevator drop to bin
- 7) Wet grain storage

2. A simple system such as the one in TM #1 will suffice for a small operation. But in cases where large amounts of grain will be stored and/or dried, more equipment may be needed. What commercial operations are in your area? See TM #2.

What are some options in a small simple-loop system?

- 1) High temperature continuous dryer
- 2) Multidirectional vertical elevator spout
- 3) Dual feed under floor conveyors
- 4) Wet grain storage

3. Expansion usually leads to problems when placing bins. Proper consideration of factors that will affect placement and efficiency need to be considered carefully.

When expanding to a large capacity closed-loop system, what factors need consideration?

- 1) Use gravity or auger feed.
 - a) Wet grain is about four times cheaper to move by gravity than auger.
- 2) Locate additional bins on either side of travel way.
- 3) Plan for vertical leg of sufficient capacity to handle loads.
- 4) Plan for "wet grain" on one side and "dry grain" on the other side.
- 5) Consider the types of conveyors for loading, unloading, and transferring.
- 6) Place gravity flow systems closest to vertical legs.

4. The proper conveyor system can cut energy costs and facilitate the movement of grains. What conveyors are available?

What are some conveyor options in a closed-loop system?

- 1) Use gravity systems especially for wet grain.
- 2) Use horizontal overhead conveyors. See TM #3. (If wet grain is handled, use a larger conveyor than for dry grain.)
- 3) Use high-capacity vertical elevators to fill load-out bins over the driveway. Load out or store overload for bin conveyors of smaller capacity. See TM #4.
- 4) Under-roof conveyors will fill slower and have higher wear than high capacity overhead augers.
- 5) Inclined conveyors can be used on small operations or for isolated bins. Moving of conveyor to other bins necessitates need for more labor. See TM #5.
- 6) An ear-corn elevator can be used effectively to move wet corn quickly.
- 7) To cut costs and power needs, use gravity whenever possible.

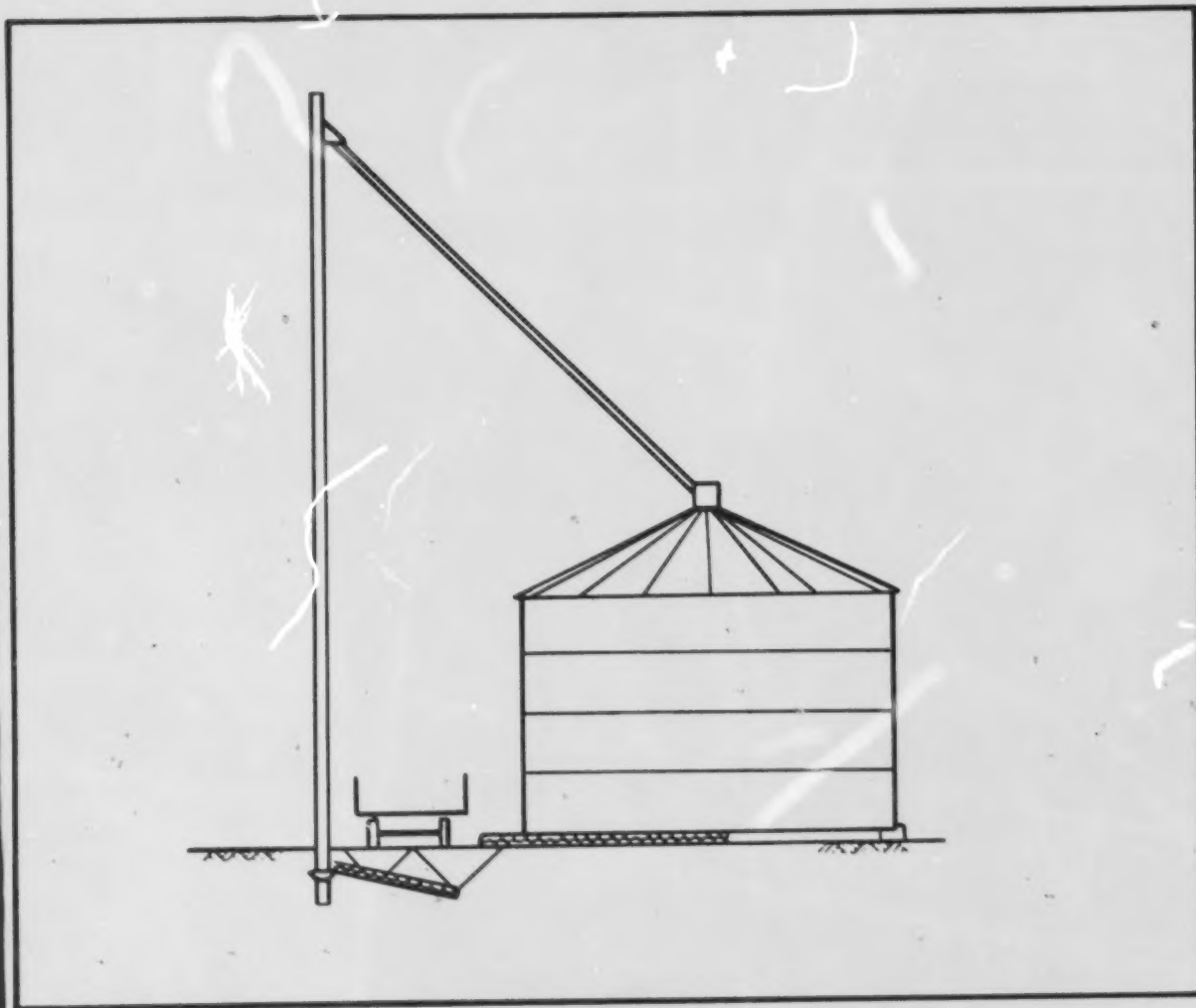
F. Summary

A closed-loop system of grain handling is considered the best because of its efficiency of operation. It needs to be planned carefully in order to allow for expansion and ease of working.

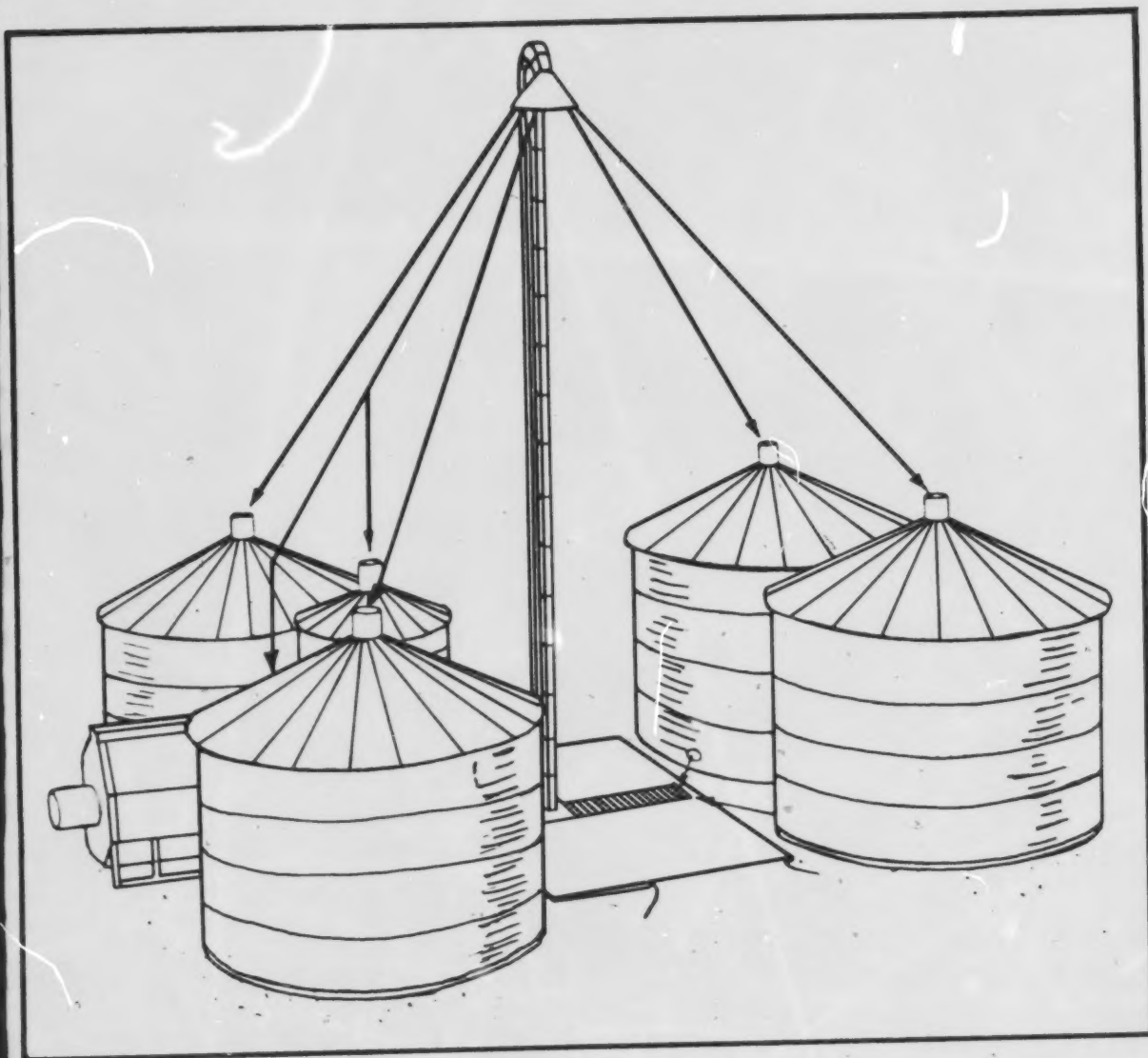
G. Evaluation

Have the students draw a closed-loop handling system including wet and dry corn bins, dryer, vertical, and other conveyors. Grade on completeness, placement of components, and ease of operation.

Components of Grain System

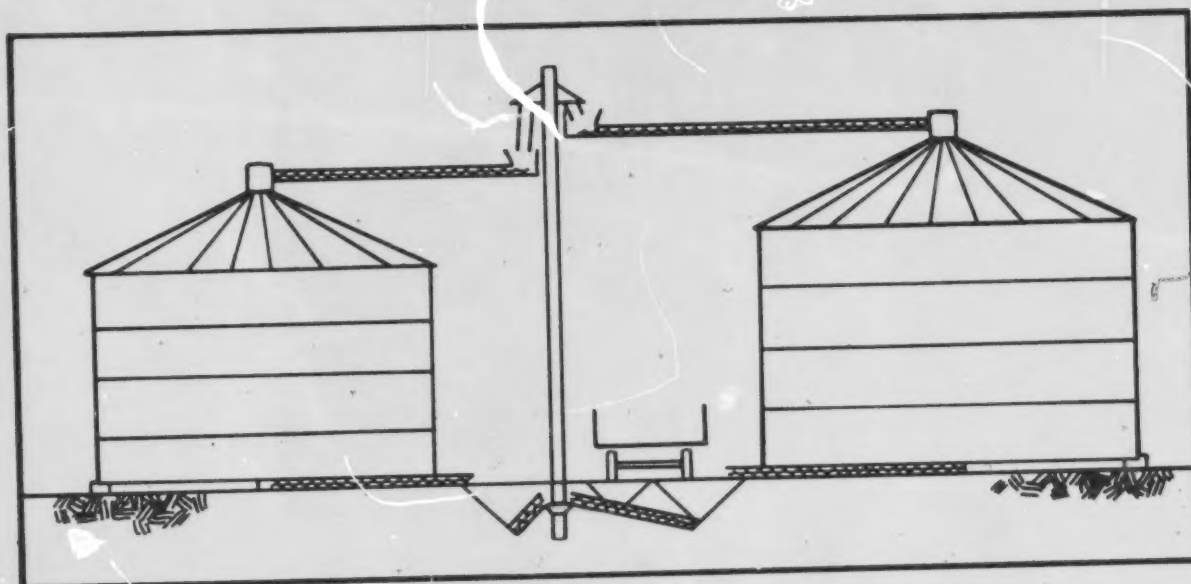


Options for Grain Systems

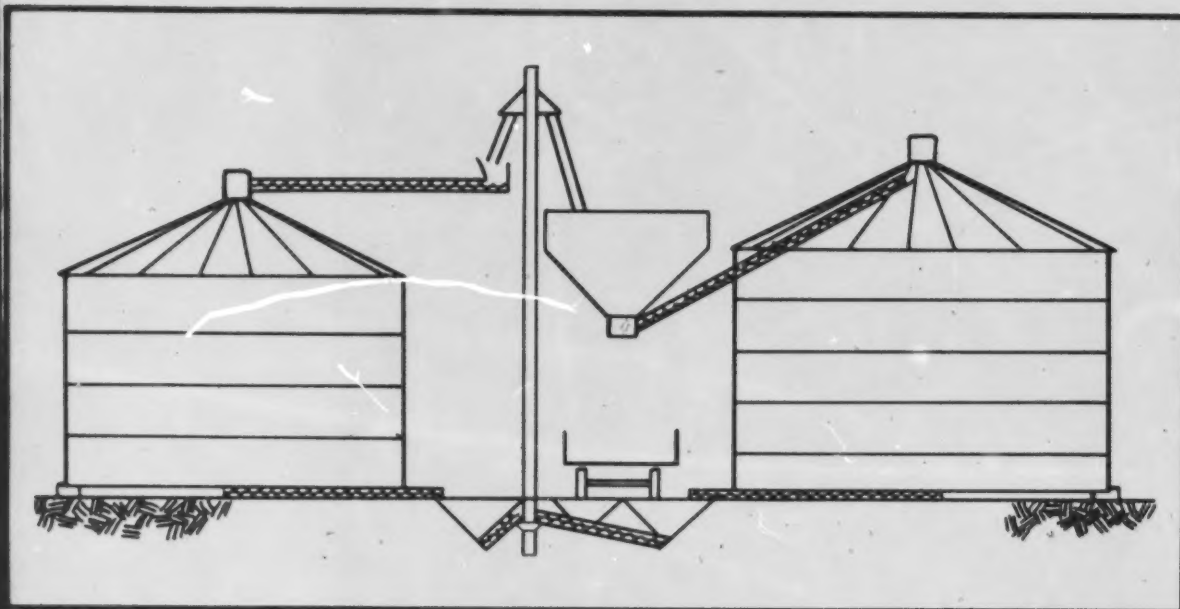


TM-2

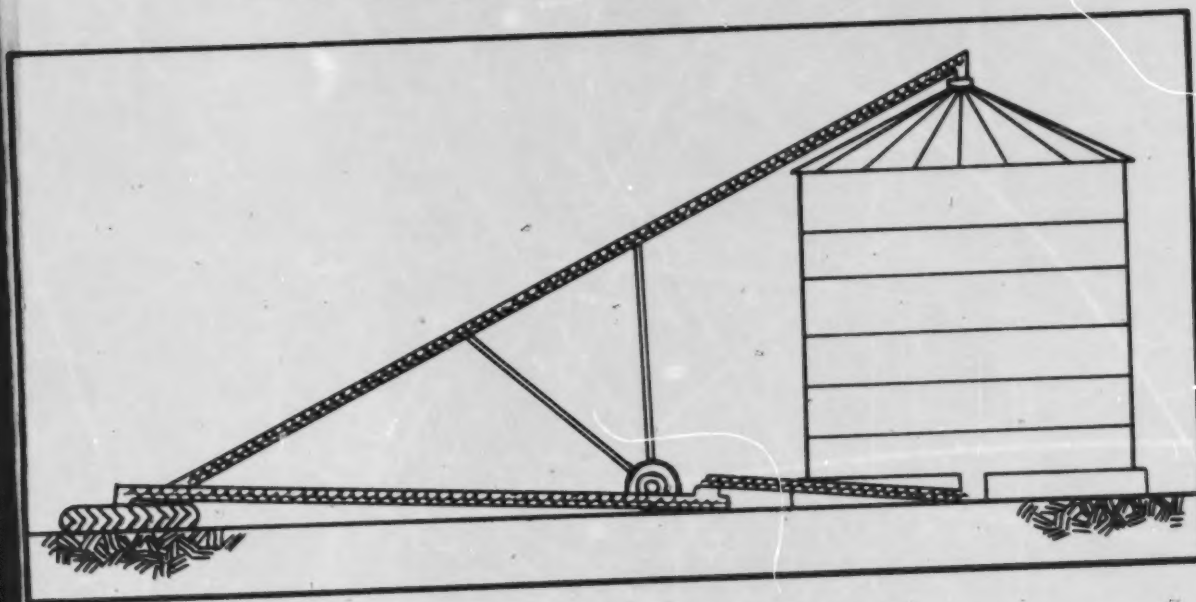
Use of Horizontal Conveyors



Hopper Use



Inclined Conveyor



UNIT - PLANNING GRAIN-FEED HANDLING

Lesson 3 - What are the flow principles affecting grain-feed handling?

Objective: By the conclusion of the lesson, the student will be able to compare gravity and conveyor systems; bin types; sizes; and uses.

Study Questions:

1. Are gravity and conveyor systems interchangeable when planning grain-feed handling?
2. What factors will affect the planning of bin types?
3. Which bin type is best for different jobs?

Reference:

1. Planning Grain-Feed Handling, MWPS-13, available through Midwest Plan Service, Extension Engineer, University of Missouri-Columbia, Mo. 65211. Cost \$2.50.

Transparencies:

1. TM #1: Gravity Versus Conveyor
2. TM #2: Systems Comparison

Handout:

1. HO #1: Bin Types, Sizes, and Uses

UNIT - PLANNING GRAIN-FEED HANDLING

Lesson 3 - What are the flow principles affecting grain-feed handling?

TEACHING PROCEDURE

- A. Review the components of a closed-loop handling system.
- B. Motivation - Is an overhead loading system better than a conveyor? How do bins differ in use? What factors will favor one type of bin over another?

C. Assignment

- D. Supervised Study - In class build small models of the different bin types and bottoms. In order to show the students the flow that occurs in each type, consider the designs in a step-by-step process.

E. Discussion

1. When planning for flow out of bins, there are two methods traditionally used - gravity and conveyor. What are the differences between these two systems?

Are gravity and conveyor systems interchangeable when planning grain-feed handling?

- 1) Gravity is not free. Money must be spent to elevate the material.
- 2) Gravity is convenient but may be highest in cost.
- 3) Gravity bins need to be elevated 10 feet above grade for loading.
- 4) If a bin is placed at grade and only the material elevated, how does the cost compare?
- 5) Overhead bins require extra supports and more total height which in turn requires taller elevators to fill them.
- 6) In contrast to overhead bins, grade level bins require less height to fill and rest on the ground which simplifies construction. The conveyors can be shifted from bin to bin.

2. The type of bin selected will be determined by size and the degree of mechanization to be employed. What different bottom types are available?

What factors will affect the planning of bin types?

- 1) Type of bottom on bin selected
 - a) Hopper bottom
 - b) Sweep unloader
 - 2) Hopper bottom can be installed to give 100 percent free flow of materials. Floor is inclined above the angle of repose.
 - 3) Bin-sweep unloader in a flat-bottom bin gives complete unloading, mechanically.
 - 4) Hopper construction is permanent and needs to be done for all bins. This construction is costly and reduces the amount of storage available.
 - 5) Sweep unloader requires little special construction and contains no wasted storage. It can often be moved from bin to bin.
 - 6) TM #2 shows the three system alternatives.
 - a) Elevated bin with gravity unloading hopper base
 - b) Elevated bin with grade level unloading hopper base
 - c) Grade level flat unloading using sweep unloader
3. Different feed types and grain types need varying bin types. What type bin is used in your area for grain? For feed? For mixers?

Which bin type is best for different jobs?

- 1) Type of bin depends on flow requirements and frequency of use.
- 2) Overhead hopper bottoms are important in feed mill operations to provide a steady controllable flow of materials and a smaller capacity than grade level.
- 3) Grade level bins with hopper bottoms are used where self-cleaning bins are necessary and quantities too large to put the bin overhead.
- 4) Work bins are surge bins between two flow rates.
 - a) A holding bin to a gravity feed
 - b) A fast load-out bin over a drive
 - c) Relatively small
 - d) Function enables process to work
 - e) Need to be in constant use
- 5) As mechanization increases, the need for overhead gravity bins decreases.
- 6) Ready-to-go mechanization, with a combination of storage, bulk, and work bins ties the process together in an efficient functioning unit which organizes the flow of materials.

F. Summary

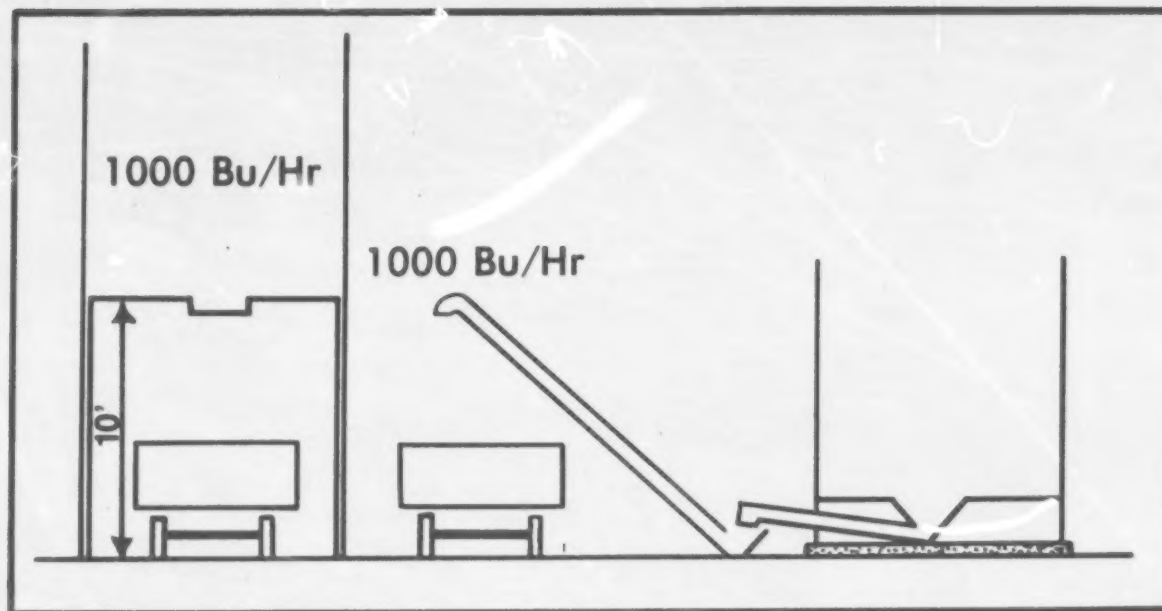
Before planning, the designer needs to understand the principles of grain and feed flow. Many factors will affect the choice made, so be sure to look carefully at need before selecting.

G. Evaluation

Answers to the Exam

1. F
2. F
3. a. hopper
b. sweep unloader
4. a. flow requirement
b. frequency of use
5. a. gravity
b. conveyor

Gravity Versus Conveyor



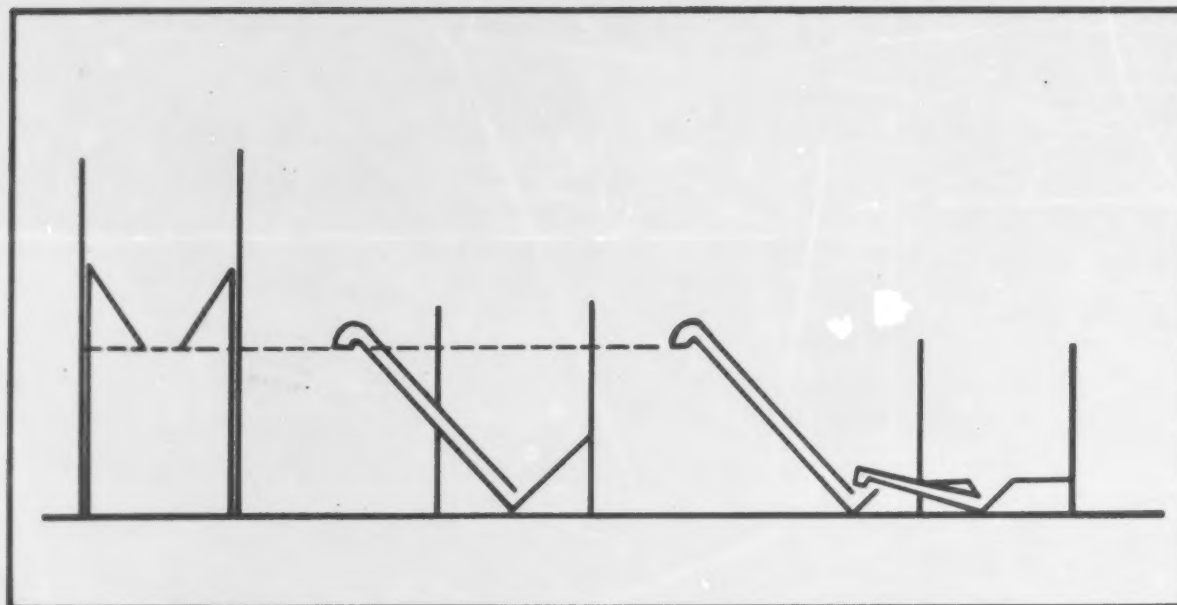
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260

261

TW-1

Systems Comparison



353

262

263

TM-2

BIN TYPES, SIZES, AND USES

Description	Grade Level Discharge Flat Bottom Bin	Grade Level Discharge Hopper Bottom Bin	Overhead, or Elevated-Discharge, Hopper Bottom Bin
Name	Storage Bin	Fulk Bin	Work Bin
Recommended Application	Grain	Feed Supplies & Ingredients	Grinding Bins, Batching Bins
Use Pattern	Usually fill once /year & unload over a relatively long time period.	Fill & unload many times/year; generally weekly to monthly	Fill & unload each daily use. Value is in choke-fed gravity flow.
Size (Relative)	Large 1000's of bushels or 100's of tons	Medium 3-30 Tons; can be large & storage bins.	Small 1/4-2 Tons
Approximate Cost/Bushel	30-40¢ (on concrete floor, no drying provisions)	\$1 to \$2	\$2 to \$4

UNIT - PLANNING GRAIN FEED HANDLING

Lesson 4 - How are handling components matched?

Objective: By the conclusion of the lesson, the student will be able to understand the importance of a proper match, the techniques used, and controlling mechanisms available.

Study Questions:

1. Why are matching components important to materials handling?
2. How is sequencing used to assume proper flow?
3. What malfunctions are common when matching systems?
4. What influence does automation have on flow?

Reference:

1. Planning Grain-Feed Handling, MWPS-13, available through Midwest Plan Service, Extension Engineer, University of Missouri-Columbia, Mo. 65211. Cost \$2.50.

Handout:

1. HO #1: Motor Controls for Conveyors in Sequence

UNIT - PLANNING GRAIN-FEED HANDLING

Lesson 4 - How are handling components matched?

TEACHING PROCEDURE

- A. Review the parts of a system.
- B. Motivation - On your farm how many motors and conveyors are there to move grain? Are all the motors equal in size? Are all the conveyors of equal capacity? What problems in material flow have you encountered?
- C. Assignment
- D. Supervised Study - As a class draw a conveyor "train". Use HO #1 to show a schematic drawing. Then discuss possible problems that could be encountered.
- E. Discussion

1. Proper component matching is important to quick and efficient materials handling. What is the importance of a proper match?

Why are matching components important to materials handling?

- 1) Match for capacity or use surge bins to buffer differing rates.
- 2) The smallest-capacity unit in the system will control flow rate.
- 3) A small surge tank between each conveyor is suggested because:
 - a) Sometimes conveyors are started in the wrong order.
 - b) Some motors will "coast" to a stop.
 - c) Conveyors may plug.
 - d) Time is required to reach operating speed.

2. Automation has removed some of the problems encountered when trying to sequence conveyors. What are these systems?

How is sequencing used to assure proper flow?

- 1) Automatic switching sequences and time delays can control entire systems.
- 2) These systems have very little farm application.

- 3) Farm systems can interlock units electrically to start the last element first. Then feed this unit through the other units.
 - 4) This interlock protects against overrun of materials.
 - 5) If overload occurs in the system, the overload shuts down the component feeding the overloaded component.
3. Malfunctions are a problem faced on anything mechanical. What problems have been encountered in the class?

What malfunctions are common when matching systems?

- 1) Belts slipping
 - 2) Pulleys turning on the shaft
 - 3) Use switches or flow-measuring devices to check levels.
 - 4) Reliability of components is more critical with greater volumes and complexities.
 - 5) Check flow rates from specifications and from farm usage.
4. Automation has freed the farmer from many of the jobs that have taken a lot of time to complete. The reliability of components requires less time spent waiting for jobs to be completed.

What influence does automation have on flow?

- 1) As automation increases and the process becomes more continuous, the flow rate can be reduced.
- 2) The process can run continuously without supervision.
- 3) Reduced flow rates encourage smaller equipment.
- 4) Judge size on "miles per year" of conveying.
- 5) Consider top or medium-quality units in a larger size which run more slowly.
- 6) Gear-head motors lend flexibility which help to increase capacity.

F. Summary

The key to a successful system is to have a system that will run efficiently and consistently. Automation is the key to labor problems, but it requires a more complex knowledge of equipment.

G. Evaluation

Answers to the Exam

1. T
2. T
3. F
4. T
5. T

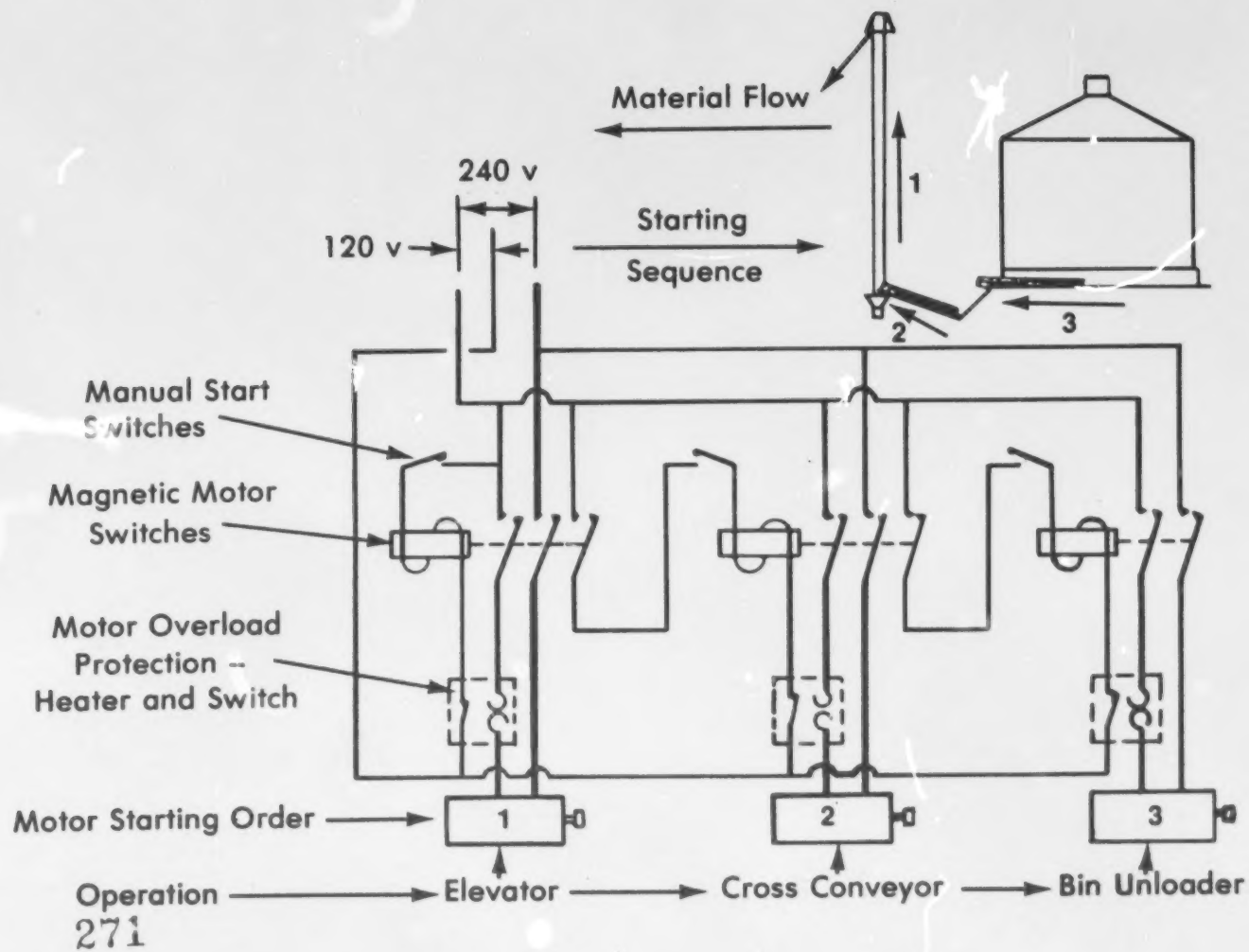
UNIT - PLANNING GRAIN-FEED HANDLING

Lesson 4 - How are handling components matched?

EXAM

- T F 1. The smallest-capacity unit in the system will control the flow rate.
- T F 2. Some motors "coast" causing a plugging in the system.
- T F 3. Interlocking systems are worthless to feed handling systems.
- T F 4. Flow rate may decrease as automation increases.
- T F 5. Always plan for expansion before purchasing conveyor equipment.

Motor Controls for Conveyors in Sequence



UNIT - PLANNING GRAIN-FEED HANDLING

Lesson 5 - What are the components of farm-materials flow?

Objective: By the conclusion of the lesson, the student will be able to identify the functions of the materials-flow process.

Study Questions:

1. What is the functional sequence in grain harvesting/handling/drying?
2. What are the equipment alternatives for each flow function?

Reference:

1. Planning Grain-Feed Handling, MWPS-13, available through Midwest Plan Service, Extension Engineer, University of Missouri-Columbia, Mo. 65211. Cost \$2.50.

Transparency:

1. TM #1: Equipment Alternatives for Each Flow Function

UNIT - PLANNING GRAIN-FEED HANDLING

Lesson 5 - What are the components of farm-materials flow?

TEACHING PROCEDURE

- A. Review
- B. Motivation - How many steps are involved in getting grain from harvest to market? What types of equipment are used in each step? Visit a local equipment dealer to see the various types of equipment.
- C. Assignment - Visit a local feed handler or grain elevator and make a design of the materials-flow system.
- D. Supervised Study
- E. Discussion
 1. There are many steps involved in the movement of grains from harvest to sale to consumers. What are the critical points of the flow sequence?

What is the functional sequence in grain harvesting/handling/drying?

- 1) Harvest
- 2) Transport
- 3) Unload
- 4) Receive
- 5) Elevate
- 6) Dry
- 7) Unload
- 8) Elevate
- 9) Transport to market OR
- 10) Process to convey

2. To perform the tasks found in the sequence, equipment for each step needs to be used. Some dual use may be possible in smaller operations.

What are the equipment alternatives for each flow function?

- 1) Use TM #1.
- 2) Harvest
 - a) Picker
 - 1) mounted
 - 11) pull type 274

- b) Picker Sheller
 - i) mounted
 - ii) pull type
 - iii) self propelled
 - c) Combine
 - i) pull type
 - ii) self propelled
 - d) Broadcast
 - i) vs. row
 - ii) 1 to 8 row
 - iii) 20"-40" spacing
 - 3) Transport
 - a) Wagon
 - i) flat bed
 - ii) gravity bed
 - iii) feed wagon
 - b) Truck
 - i) straight
 - ii) pick up
 - iii) semi
 - 4) Unload
 - a) Hydraulic
 - b) Gravity
 - c) Hoist, wheel
 - 5) Receive
 - a) Drive-over dump
 - i) gravity
 - ii) auger
 - iii) chain
 - iv) oscillatory
 - b) Drag
 - i) hinged
 - ii) portable
 - c) Hopper
 - i) attached
 - ii) separate box, tire
 - 6) Elevate
 - a) Inclined
 - i) chain: single, double
 - ii) auger
 - b) Vertical
 - i) bucket: belt, chain
 - ii) auger
 - iii) blower
 - 7) Dry
 - a) In-bin
 - i) layer
 - ii) batch
 - b) Portable or stationary
 - i) batch: manual, automatic, recirculating, nonrecirculating
 - ii) continuous flow: horizontal, tower

- 8) Store
 - a) Metal bins
 - i) round
 - ii) flat
 - iii) hopper
 - b) Silos
 - i) concrete
 - ii) steel
 - c) Wood Buildings
 - i) crib conventional
 - ii) others
- 9) Unload
 - a) Sweeps
 - b) Auger
 - c) Chain
 - d) Manual
- 10) Elevate
 - a) Inclined
 - i) chain: single, double
 - ii) auger
 - b) Vertical
 - i) bucket: belt, chain
 - ii) auger
 - iii) blower
- 11) Cash grain: transport to market
 - a) Truck
 - i) straight
 - ii) pick up
 - iii) semi
 - b) Wagon
 - i) all types

OR

- 12) Livestock: process to convey
 - a) Blender-grinder
 - b) Grinder-mixer
 - i) stationary
 - ii) portable
 - c) Conveyor
 - i) auger
 - ii) chain
 - iii) belt
 - iv) air
 - d) Vehicle
 - i) feed wagon: truck, wagon

F. Summary

Prior planning of the flow sequence will increase efficiency, reduce labor need, and help reduce grain loss. Carefully plan the flow of materials before moving the grain.

G. Evaluation

Answers to the Exam

1.
 - a. harvest - picker
 - b. transport - wagon
 - c. unload - hydraulic
 - d. receive - drive-over dump
 - e. elevate - vertical bucket
 - f. dry - batch dryer
 - g. store - metal bin
 - h. unload - sweep
 - i. elevate - inclined drain
 - j. cash grain transport - truck

OR

- k. livestock process - grinder-mixer

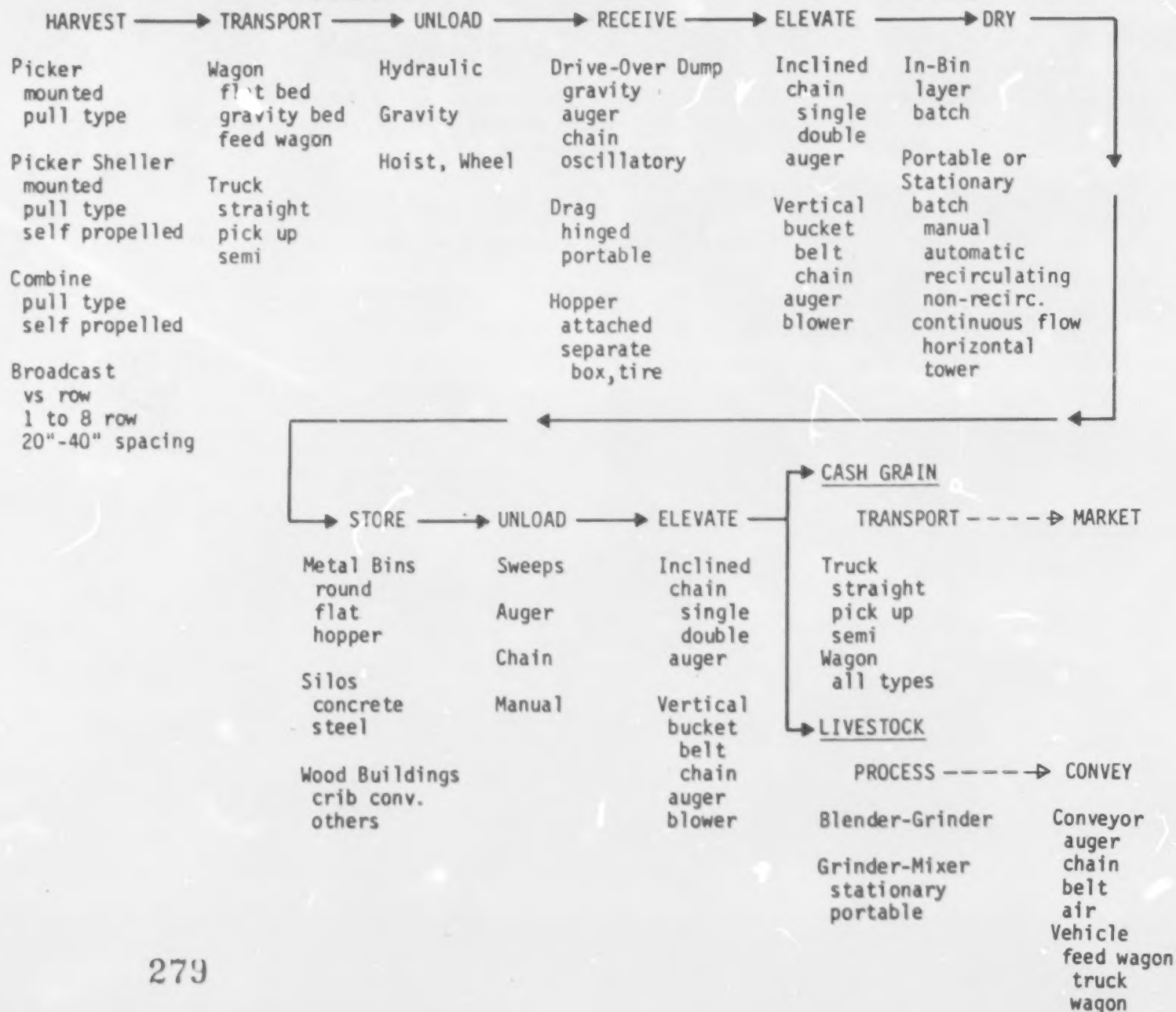
UNIT - PLANNING GRAIN-FEED HANDLING

Lesson 5 - What are the components of farm-materials flow?

EXAM

1. What are the steps in the farm-materials flow and list an example of a piece of equipment used in each step?
 - a.
 - b.
 - c.
 - d.
 - e.
 - f.
 - g.
 - h.
 - i.
 - j.
 - k.

Equipment Alternatives for Each Flow Function



UNIT - PLANNING GRAIN-FEED HANDLING

Lesson 6 - How are storage methods evaluated?

Objective: By the conclusion of the lesson, the student will be able to list the factors which affect storage; understand the various drying methods; and discuss the storage of high-moisture and chemically-treated corn.

Study Questions:

1. On what factors do storage systems depend?
2. What are some storage tips for dry grain?
3. What factors will affect the selection of a grain drying system?
4. What are the types of bin dryers?
5. What are the types of batch and continuous flow dryers?
6. Why and how is grain cooled after drying?
7. What methods are used to store high-moisture and chemically-treated corn?

Reference:

1. Planning Grain-Feed Handling, MWPS-13, available through Midwest Plan Service, Extension Engineer, University of Missouri-Columbia, Mo. 65211. Cost \$2.50.

Transparencies:

1. TM #1: Bin Drying
2. TM #2: Batch and Continuous
3. TM #3: Cooling Grain
4. TM #4: Treating Grain

UNIT - PLANNING GRAIN-FEED HANDLING

Lesson 6 - How are storage methods evaluated?

TEACHING PROCEDURE

A. Review

- B. Motivation - How do you start the planning process for grain handling? Is storage the same for wet, dry, high-moisture and chemically-treated corn? Are all grain dryers built equally?

- C. Assignment - Find out what types of grain dryers are used in your area. Discuss the types, their capacities, and their costs.

- D. Supervised Study - Bring in brochures of the different types of grain dryers. Discuss capacities, power needs, and speed of drying.

E. Discussion

1. Storage system needs will vary from farm to farm. What will determine the system found on your farm or your neighbor's farm?

On what factors do storage systems depend?

- 1) Type and size of the operation
- 2) Total annual grain production
- 3) Harvesting methods and rates
- 4) Existing storage facilities
- 5) Personal experience and preferences
- 6) Future plans

2. Dry grain can be fed on the farm or marketed commercially. But wet grain cannot be marketed commercially because of molding and handling problems. Drying grain for storage over long periods is essential but only down to moisture levels that will allow safe storage. What are these levels?

What are some storage tips for dry grain?

- 1) Only remove the water necessary for safe storage. The cost of removing the extra water from the grain could exceed the price for which the grain could be sold.

- 2) Safe storage levels
 - a) Hold to spring = 15 1/2% moisture
 - b) Up to 1 year = 14% moisture
 - c) Over one year = 13% moisture
- 3) Drying to 11% instead of 14% cuts the yield of grain by 3.4 bushels per 100 bushels.
- 4) Aeration is important to quality.
 - a) It maintains uniform temperature.
 - b) It prevents moisture migration.
- 5) Higher moisture grain (up to 22%) can be stored for feed in winter if held below 50°F.
3. Selection of the correct components to complete a drying system for grain is very important. What goes into a system?

What factors will affect the selection of a grain drying system?

- 1) Compare drying alternatives:
 - a) For drying capacity.
 - b) For investment necessary to get that capacity.
- 2) Drying temperature
- 3) Air flow
- 4) Fan horsepower
- 5) A 15 operating-day season is a realistic design per season.
- 6) Balance cost of increased harvest, handling, drying capacity against value of anticipated increased field loss due to a severe storm.
- 7) Plan for expansion of grain.
 - a) More production requiring more storage
 - b) Higher harvest rate requiring wet grain storage
 - c) Different grain types such as corn, wheat, etc.
 - d) Additional processes such as grinding, mixing, etc.
- 8) Custom harvesting can increase daily harvest.
4. There are many types of dryers. How many can the class name and describe? Use TM #1.

What are the types of bin dryers?

- 1) Three types of dryers are bin, batch, and continuous flow.
- 2) Bin dryer types
 - a) Low-temperature dryers
 - b) High-temperature dryers
 - c) High-capacity
 - d) Continuous-flow bin

5. Is there a difference between dryer types? List the differences along with the portability. Use TM #2.

What are the types of batch and continuous flow dryers?

- 1) Self-contained, column types, transportable
 - 2) Batch dryers
 - a) Recirculating batch
 - b) Portable batch
 - c) Automatic batch
 - d) Staged batch
 - 3) For each dryer type review the characteristics and range of annual production.
6. Drying the corn can be a high investment item in the raising of grains. To insure a lower cost once the moisture is out, it needs to be kept out. Use TM #2.

Why and how is grain cooled after drying?

- 1) Cooled to minimize moisture migration level in storage.
 - 2) Cooled to provide a more suitable storage environment.
 - 3) Can be cooled in:
 - a) Dryer
 - b) Aerated storage in bins which is the easiest method of cooling grain
 - c) Separate cooling bins which will increase the most cooling capacity
 - 4) Slowly cooled grains crack less.
 - 5) Delay cooling 4 hours to equalize moisture.
 - 6) One-half cubic foot per minute of air flow is needed per bushel of grain.
7. High-moisture grain storage is often the easiest and best system. Care must be taken to prevent spoilage, but systems are available to handle the problems. Use TM #4.

What methods are used to store high-moisture and chemically-treated corn?

- 1) Horizontal, sealed, or conventional upright silos can be used for high-moisture corn.
- 2) Conventional silos need to be fed from 3 to 4 inches per day to prevent top spoilage.
- 3) The rule is to seal out air either by compaction or by artificial means (air-tight).
- 4) To minimize problems in trench silos:
 - a) Fill rapidly.
 - b) Cover surface with plastic.

- c) Remove grain rapidly before heat builds up.
- d) Grind before storing.
- 5) Grains can be treated with propionic acid or some acetic acid to prevent spoilage.
- 6) Treated corn has better summer tolerance than high-moisture corn.
- 7) Problems: Costs are high. Chemicals can be toxic to applicator.

F. Summary

There are several options open to the farmer when it comes to storage of crops. The best system for each farmer will depend on the use of the grain, the amounts of grain, and the storage currently available.

G. Evaluation

Answers to the Exam

1. Any three of the following:

- Type and size of operation
- Annual Production
- Harvest method and rate
- Storage facilities
- Personal experiences
- Future plans

2.
 - a) 15 1/2% moisture
 - b) 14% moisture
 - c) 13% moisture
3.
 - a) Maintain uniform temperature
 - b) Prevent moisture migration
4.
 - a) Bin
 - b) Batch
 - c) Continuous-flow
5.
 - a) Propionic acid
 - b) Acetic acid

UNIT - PLANNING GRAIN-FEED HANDLING

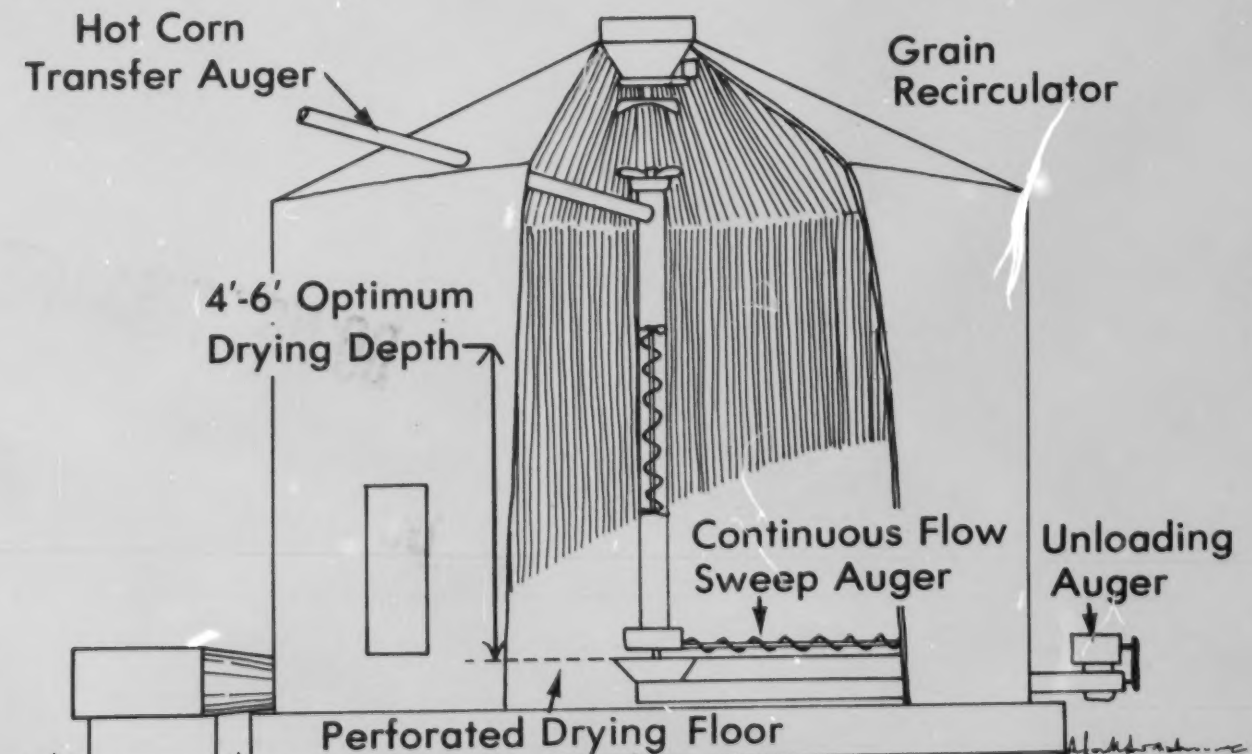
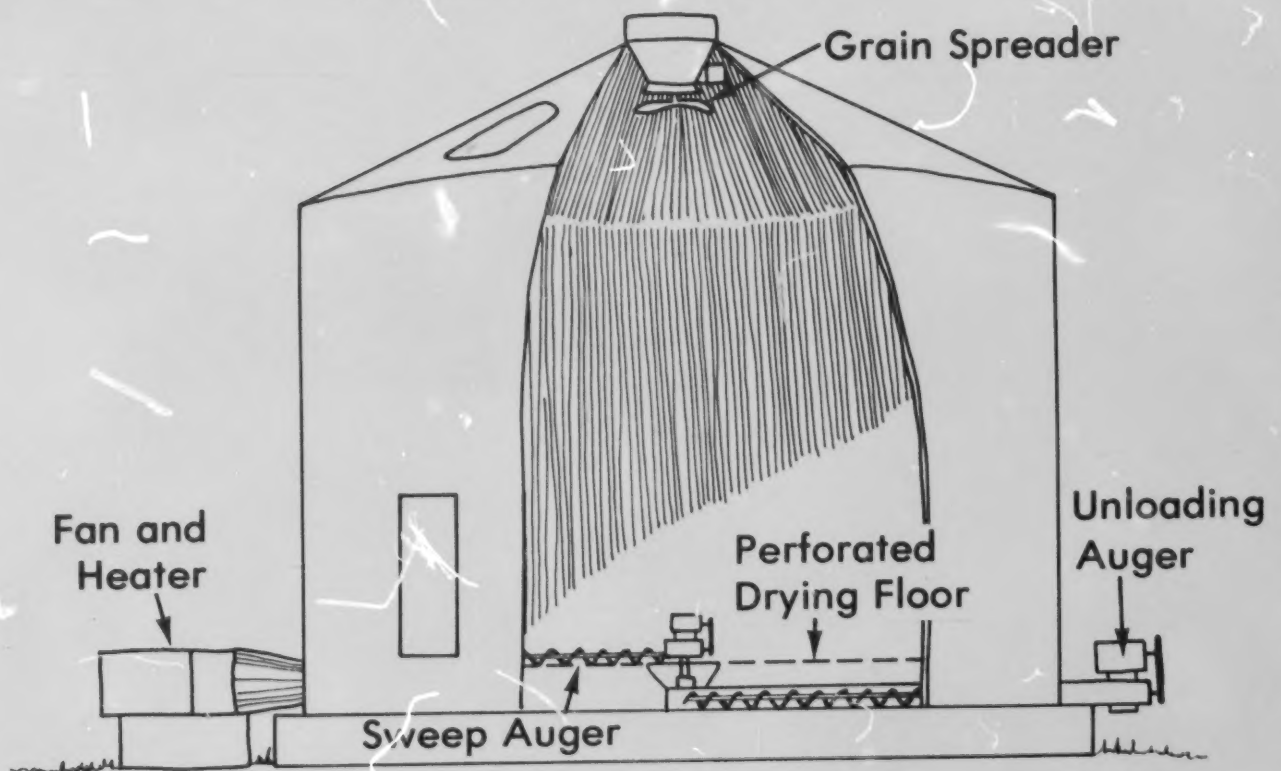
Lesson 6 - How are storage methods evaluated?

EXAM

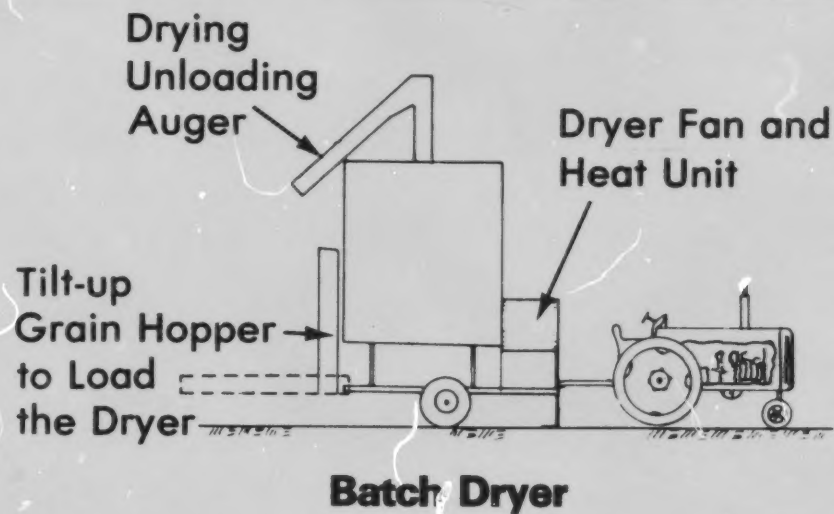
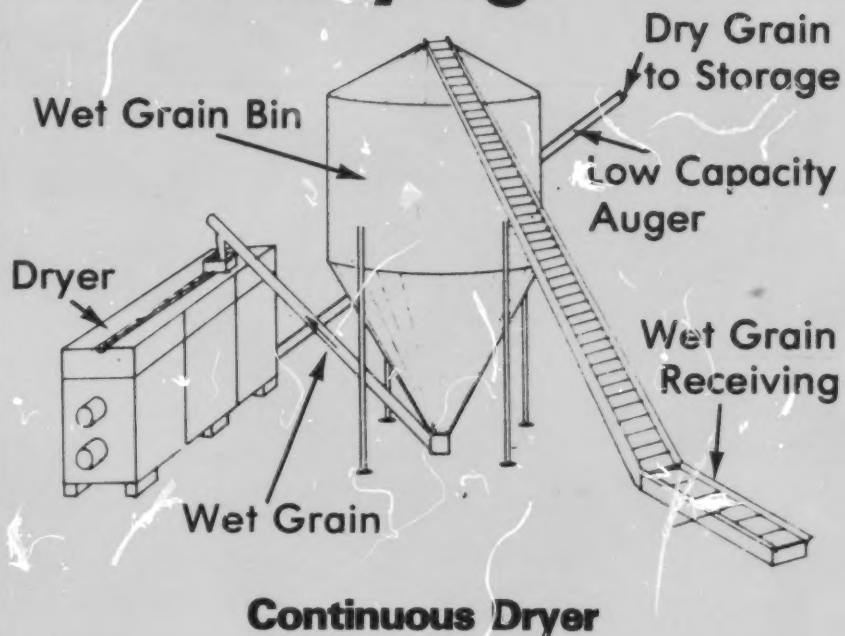
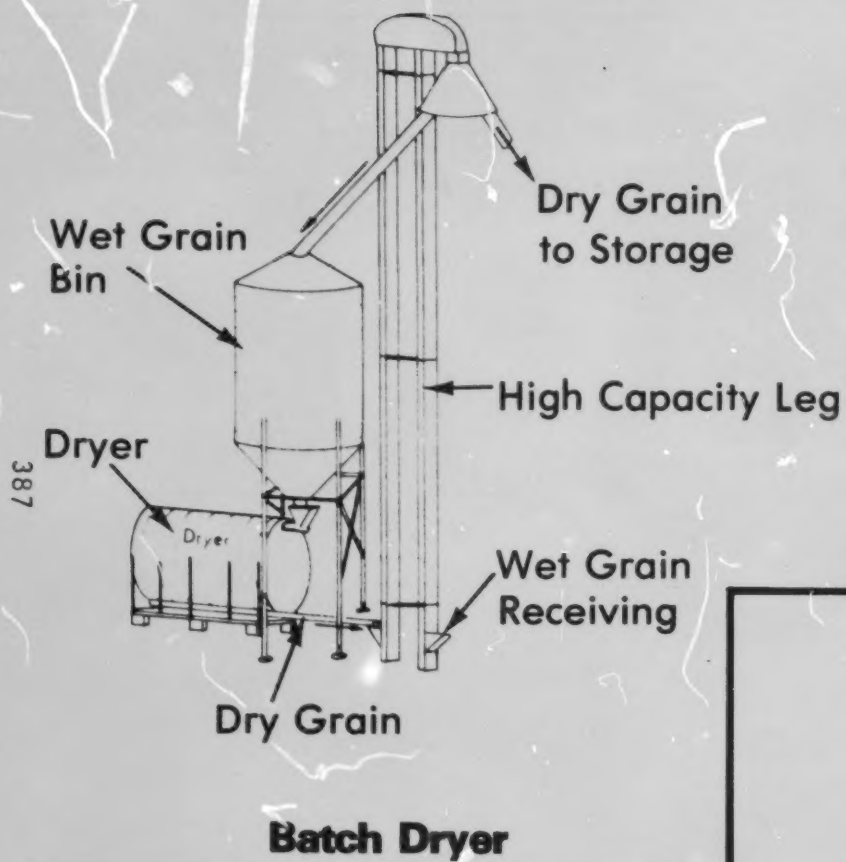
1. List three factors on which storage systems depend.
 - a.
 - b.
 - c.
2. What are the moisture safe storage levels if grain is held until:
 - a) Spring _____%
 - b) One year _____%
 - c) Over a year _____%
3. Why should stored grain be aerated?
 - a)
 - b)
4. What are the three types of degrees?
 - a)
 - b)
 - c)
5. What chemicals can be used to store grains?
 - a)
 - b)

Bin Drying

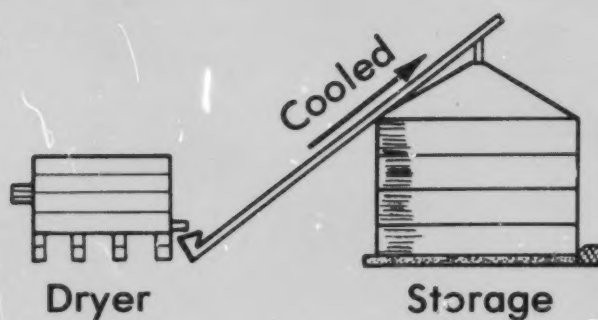
TM-1



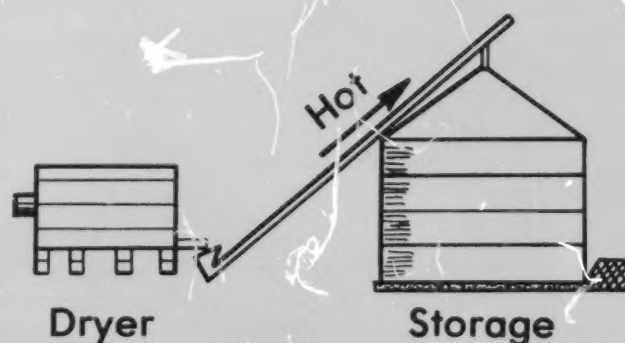
Batch and Continuous Drying



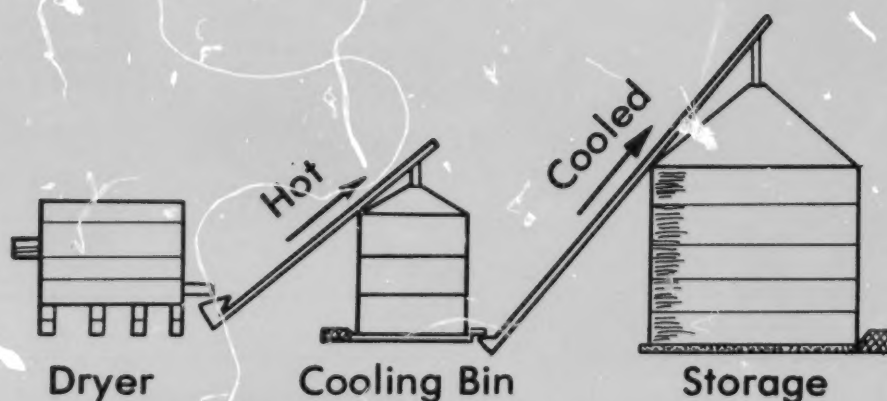
Cooling Grain



Grain Cooled in Dryer

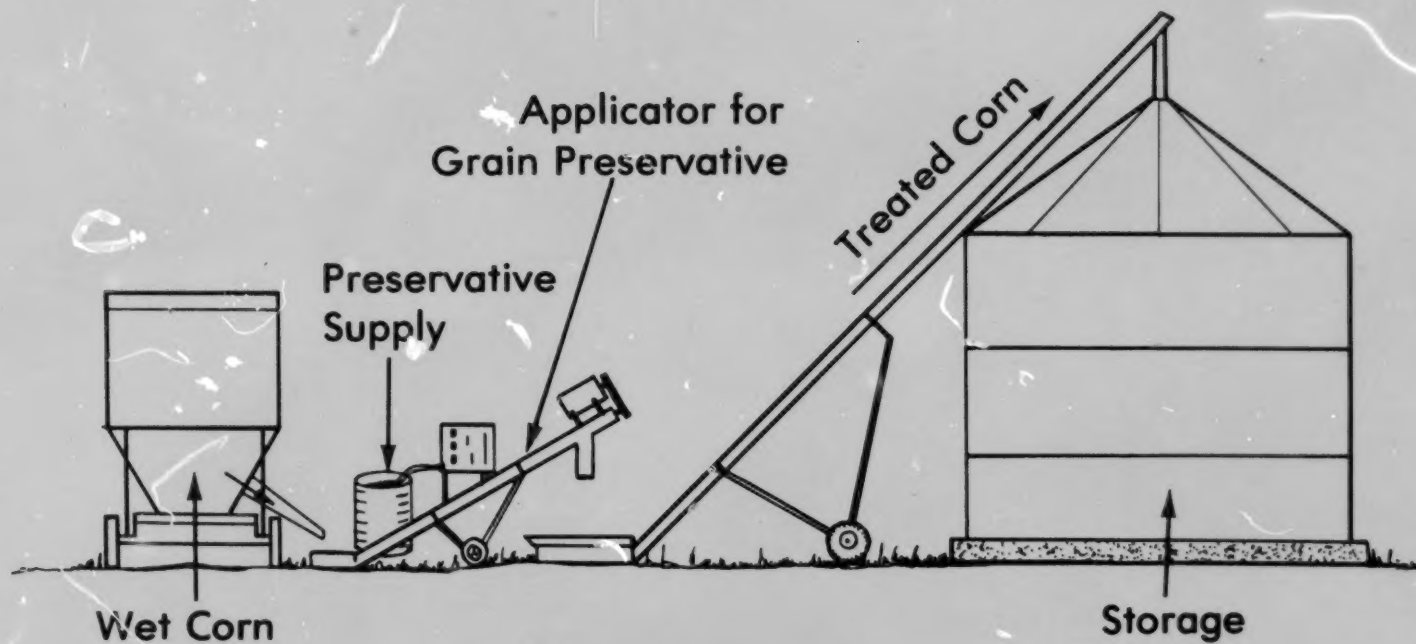


Grain Cooled in Storage



Grain Cooled in Cooling Bin (Dryeration)

Treating Grain



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291

TM 2
291

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 1 - What are the components of electrical safety instruction?

Objective: At the conclusion of the lesson, the student should be aware of the terms, dangers and safety practices associated with electrical work.

Study Questions:

1. What are the terms, definitions and basic rules of electrical safety?
2. What are the terms and definitions of electricity?
3. What are the sources of electrical defects in equipment?
4. What do you do if you or someone else gets shocked?
5. What are the types of circuit protection?

References:

1. Agricultural Wiring Handbook, Food and Energy Council, Inc., 909 University Avenue, Columbia, MO 65211.
2. Modern Agricultural Mechanics, T.J. Wakeman. The Interstate Printers and Publishers, Inc.
3. Wiring Simplified, H.P. Richter. Park Publications Inc., 1999 Shepard Road, St. Paul, MN 55116. Available through IML, UMC.
4. Practical Farm Wiring Demonstrations, by Curtis Weston. Edition I or II.

Handouts:

1. HO #1: Terms Associated With Wiring Buildings

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 1 - What are the components of electrical safety instruction?

TEACHING PROCEDURE

A. Review

- B. Motivation - Use static electricity to jump a spark or use a heating coil and a piece of paper to show heat produced.

C. Assignment

- D. Supervised Study - Practical Farm Wiring Demonstrations;
Section 1: Exercises B, C, D, F.

E. Discussion

1. Safety is a very important part of any instructional unit and time to thoroughly discuss electricity is a major consideration. Use HO #1.

What are the terms, definitions and basic rules of electrical safety?

- 1) A fuse is a safety device which breaks the flow of electrical current when a circuit becomes overloaded by burning out a metal strip.
 - a) Never replace a blown fuse with one of higher amperage because it could overheat the wires.
 - b) Never put a penny or foil into the fuse box because doing so eliminates the protection from shocks and overheating.
 - c) If a fuse blows, find the source of the problem before replacing it.
- 2) The National Electrical Code is a handbook that sets minimum standards for wiring and materials that can be used when wiring a structure.
 - a) Reading the book before installing will save problems later through inspections and/or problems with the wiring.
 - b) Safety is stressed throughout the text.
 - c) If in doubt about installation hire an electrician to check your plans or procedures before starting to install wiring.
- 3) Test lamps are helpful when testing a newly installed system for short circuits, hot lines and voltages.
 - a) Several types are available.
 - b) The simplest being a plug-in type that lights a sequence of lights for each type of problem.
 - c) Test lamps are important in finding shorts, open circuits and grounds.

- 4) For equipment that has a surge of amperage when it starts, such as an auger motor, the system should be protected by a fuse-tron.
 - a) A fuse-tron is a double element time-delay fuse designed to withstand momentary overloads.
 - b) A normal fuse would blow each time the motor was started.
- 5) The grounded wire is a green or bare wire which serves as the third wire on 120-volt appliances to provide an easy path for electricity to flow from hot to safety ground in a shorted piece of equipment.
 - a) Without the safety-ground wire a shortened circuit could use you as the ground shocking or electrocuting whoever comes in contact with it.
- 6) A circuit is a completed path through which electricity flows.
- 7) A circuit breaker is a safety device which breaks the flow of electrical current when a circuit becomes overloaded by tripping a breaker switch.
- 8) A ground fault is an unintended voltage leak into the ground.
 - a) It can be avoided by installing a ground-fault interrupter which detects any voltage leak to the ground.
- 9) A safe practice is to buy materials that have been tested by Underwriters' Laboratories. (UL)
 - a) The UL seal says that the material being used has been tested and meets a set of minimum standards set by industry.
- 10) Whenever you work on the electrical system, disconnect the main power source.
- 11) Never work with electricity in areas that are wet, damp, or in contact with water unless circuit is de-energized.
- 12) The grounding of the electrical system is both easy and useful.
 - a) When installing the system in the building, use fixtures that offer the grounding plug.
 - b) When using 3-prong, grounding-type plugs, it is important to have the ground protection to prevent shocks.
- 13) Watch for the overloading of circuits especially when installing new equipment.
 - a) The wiring must be planned to handle the amperage of the load.
 - b) If it is anticipated that motors, heaters or other high energy units are to be installed, adjust the wire size to match the need.

2. In order to properly understand the workings of electricity, a study of the terminology used is required first.

What are the terms and definitions of electricity?

- 1) Alternating current (AC) is the term used to describe the reversing of the current at regular intervals, usually 60 cycles per second.
 - a) Most on farm electrical work will deal with this type of electricity.
- 2) Ampere (amp) is the unit of measure of electricity that describes the rate of flow through a wire.
- 3) A circuit is a complete path of electricity.
- 4) Circuit breaker is a safety device that opens the circuit by tripping a switch.
- 5) Conductors are metals that will conduct electricity; copper is best, aluminum is second best.
- 6) Direct current (DC) is electricity that flows only in one direction at a continuous rate. Tractor and automobile electrical systems are examples.
- 7) Electricity is a source of energy that can easily be converted into light, heat, and power.
 - a) It is produced by hydro, fuel-fluid or nuclear generators and transmitted to the farm over high tension electric power lines.
 - b) It can also be produced on the farm by gasoline or diesel driven generators or PTO powered units.
- 8) A fuse is a protection device that opens the circuit when the current becomes too great.
- 9) Grounding is the connection of the neutral part of the electrical system to the earth to minimize the danger of electric shock.
- 10) Horsepower (hp), is a unit of mechanical power which equals 746 watts of electrical power.
 - a) For calculation considerations the value of 1000 watts is used as a rule to allow for losses due to friction, etc.
- 11) Hot wires are the red or black conductors in an electric circuit and should be handled carefully.
 - a) Although they are usually fused, moisture could complete the circuit from the hot wire to you to the ground.
- 12) Insulation is the protective covering over the wires, usually plastic or rubber, which protects you from the electric current.
- 13) One kilowatt (KW) is equal to 1000 watts.
- 14) A kilowatt-hour (kwh) indicates the use of 1000 watts of electricity for one hour; costs are calculated from kilowatt-hours.

- 15) The electric meter is an instrument which records the amount of electricity used in kwh.
- 16) The neutral wires are the current carrying conductors with no pressure on them (usually white), connected to the neutral base at the distribution panel.
- 17) Resistance (ohms) is the opposition to flow of the current as it flows through a conductor.
- 18) The service transformer is an alternating current device used to change voltage from primary to secondary.
- 19) A short circuit is an improper connection between the hot and neutral wire or 2 hot wires.
- 20) Single-phase power is a single transformer type of power satisfactory for most farms.
- 21) A switch is a device used to open or close a circuit.
- 22) Three-phase current requires three transformers and provides more electrical pressure for heavy electrical equipment.
- 23) Volt is the measure of the electrical pressure on the line.
- 24) Voltage drop is the loss of electrical pressure from the source to the point of use.
- 25) Watt is the measure of power of electricity.
 - a) It is a measure used in determining the rate of energy supplied.
 - b) Watts can be calculated by multiplying amps x volts.

3. Equipment itself can be a hazard to the farmer or the farm building. Care must be taken to protect the individual from shock and the building from fire.

What are the sources of electrical defects in equipment?

- 1) Having a ground wire missing, broken, improperly connected or not connected at all could cause a short or shock to anyone using equipment plugged into this line.
- 2) Open conduits invite damage to the wires within.
 - a) Water damage (short)
 - b) Exposure to wear (cutting) is possible.
- 3) Worn, wet or oily insulation can cause a short circuit.
- 4) Defective switches, receptacles, extensions or lamp cords and lamp sockets can cause shock if you provide the ground.
- 5) Dirty, improperly adjusted electrical equipment can overheat, throw sparks, or short.

- 6) If machinery is run with loose, vibrating parts, it could cause the motor to short circuit.
 - 7) Old cracked insulation around wires should be replaced with new wire to prevent an electrical problem. Some signs of old wiring include:
 - a) Fuses blow
 - b) Circuit breakers trip frequently
 - c) Lights dim
 - d) Lights blink or flicker
 - e) Motors run slow
 - f) Light bulbs burn out quickly
 - g) Television picture shrinks
 - 8) Most of the problems are caused by carelessness, misuse, improper wiring, lack of knowledge, and water; but carelessness is the prime offender.
4. Have you ever been shocked or wondered what to do if you see someone else being shocked? Thinking about the situation and carefully dealing with the problem could save a life, yours too!

What do you do if you or someone else gets shocked?

- 1) To free someone who is receiving an electric shock of 120-140 volts you should:
 - a) Try to disconnect the source of electric current.
 - b) Decide immediately whether it would be easier to move the person or the conductor.
 - i) If the conductor is to be moved, use a nonconductive material, i.e., wood stick.
 - ii) Same holds true for the person.
 - c) Insulate yourself from the person and then move the person from the conductor.
 - i) Watch for fluids around the person.
 - ii) If you step into water trying to save the person, you could get shocked.
- 2) If the voltage is over 240:
 - a) Assume a downed wire is hot and can kill!
 - b) Keep people at least 200 feet away to prevent injury to anyone else.
 - c) Call power supplier immediately and give the exact location of the trouble.
 - d) If power lines are down, stay clear and keep livestock clear of any water sources in the immediate area.
- 3) Don't be a hero and try to grab the person in contact with a live wire, the current will freeze your muscles and you will not be able to free yourself.

- 4) First aid for a shock victim is to:
 - a) Call a doctor or ambulance immediately.
 - b) Treat with mouth-to-mouth resuscitation if breathing has stopped; or use CPR to restart the heart.
 - 5) The factors that contribute to death from electric shock are:
 - a) Current (amperage) kills, not the voltage.
 - b) Voltage is involved.
 - c) Less than .25-amps will stop the heart.
5. In order to protect the worker and livestock from shock or the building from fire, a method of protection is needed. The protection of a circuit involves a way to open the circuit if a short or overload occurs.

What are the types of circuit protection?

- 1) The amperage in any wire is limited to the maximum permitted by using what the Electrical Code calls an overcurrent device.
 - a) Two types are in common use: fuses and circuit breakers, both rated in amperes.
 - b) The size of the wire will determine the size (ampacity) of the overcurrent device.
- 2) A fuse is a short piece of metal that has been experimentally tested to melt at a pre-determined flow of amps.
 - a) The metal is housed to protect someone from the hot metal spattering, which also facilitates replacement.
 - b) The most ordinary fuse type is the plug which screws into the panel.
 - c) Do not replace a low amp fuse with a higher one just because it blows often.
 - d) This could cause an overheating of the wires.
- 3) Time-delay fuses are used when a high surge of amperage is needed to start equipment and lower amperage is needed to run the equipment.
 - a) The first surge would blow an ordinary fuse, so a time-delay fuse is used to prevent constant shutdowns.
- 4) Cartridge fuses in the ferrule type (round copper contacts on each end) are used in systems of 60 amps or less and knife-blade cartridges are used in systems rated over 70-amps.

- 5) A circuit breaker looks like a toggle switch with a handle that has four positions: on, tripped, off and reset.
 - a) Inside each breaker is a fairly simple mechanism which in case of an overload, trips the breaker and disconnects the load.
 - b) A circuit breaker has a definite time-delay to allow for the starting of motors.
 - c) The advantage of the circuit breaker is the ease at which it can reset.
 - d) Most construction now uses circuit breakers.
- 6) Ground-Fault Circuit-Interrupters (GFCI) are specially designed current sensing devices that detect as little as 5/1000-amperes of current flow; and then cuts current instantaneously to provide personal protection.

F. Summary

Safe material and safe practices will protect the electrical worker from harm on the job. A good understanding of the problems that occur and what to do if problems do occur can save yours or someone else's life.

G. Evaluation

Answers to Exam

1. e
2. a
3. f
4. j
5. i
6. h
7. b
8. d
9. c
10. g

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 1 - What are the components of electrical safety instruction?

EXAM

Match the terms and definitions.

- | | |
|---------------------|---|
| _____ 1. AC | a. Complete path of electricity |
| _____ 2. Circuit | b. Protection covering wires |
| _____ 3. Conductor | c. Current flows in one direction |
| _____ 4. Fuse | d. Minimizes electric |
| _____ 5. Volt | e. Current reverses direction |
| _____ 6. Resistance | f. Metals which conduct electricity easily |
| _____ 7. Insulation | g. Rate of flow of current |
| _____ 8. Ground | h. Fighting the flow electricity |
| _____ 9. DC | i. Pressure of electricity |
| _____ 10. Ampere | j. Opens switch one time by melting metal strip |

Terms Associated With Wiring Buildings

HO-1

AMPACITY: Current-carrying capacity of a conductor expressed in amperes.

AMPERE (A): A unit of measure of the rate of flow of electricity through a wire. Electricity may be thought of as a movement of electrons caused by a voltage. Understanding is sometimes aided by comparing with the rate of flow of water through a pipe. (If a 60-W incandescent lamp is used on a 120-V circuit, $\frac{1}{2}$ A of electric current will flow through the circuit.)

BRANCH CIRCUIT, GENERAL PURPOSE: That portion of the wiring system extending from the branch-circuit fuse or circuit breaker to the outlets for general use, such as lighting and convenience outlets.

BRANCH CIRCUIT, INDIVIDUAL: A circuit installed to supply a single motor or appliance. (In general, any stationary appliance of 1500 watts (W) or of $\frac{1}{2}$ horsepower (hp) or over, should be wired on such a circuit.)

CIRCUIT BREAKER: A time-delay circuit interrupter that automatically opens the circuit when too much current flows. To restore service, it is necessary to reclose switch after identifying and correcting trip cause.

CONVENIENCE OUTLET: The plug-in receptacle. The grounding-type duplex receptacle is required by the National Electrical Code (NEC) except for replacement on existing ungrounded circuits. All convenience outlets recommended in this Handbook are considered to be of grounded-type, unless otherwise noted.

FEEDER: The conductor extended from a distribution panel in one building to the service entrance conductors of another building or from distribution panel to branch-circuit panel in the same building. For design purposes, the term "feeder" will also be applied to the service drop or underground conductors which connect a polemeter installation to the service entrance conductors of each building served from the meter pole.

FLOOR AREA: Where used as the basis for requirements in this Handbook, floor area shall be computed from the outside dimensions of the building and the number of floors. In connection with the farm residence, the floor area of open porches, garages and unfinished spaces in the basement and attic shall be excluded in computing the floor area, unless adaptable for future use.

FUSE: A fuse is a device to protect against too much current flow in conductors. It has a circuit-opening fusible member directly heated and destroyed by the passage of too much current through it. A fuse will carry its rated current indefinitely, but will melt and break the circuit when the current becomes excessive from a safety standpoint. Fuses are made in both plug and cartridge type. Plug fuses are not available in sizes above 30 amps.

GROUND FAULT CIRCUIT INTERRUPTERS (GFCI): GFCI's are specially designed current sensing devices that detect as little as 5/1000 amperes of current flow; and then cuts circuit current instantaneously to provide maximum personal protection. GFCI's are available for permanent installation at the service entrance and/or as a portable protection device (for operating portable tools, etc.).

HORSEPOWER (hp): A unit of mechanical power equal to 746 W of electrical power. One kw, therefore, equals about $1\frac{1}{3}$ hp. No motor is 100 percent efficient; therefore, when estimating the operating cost of a motor (of 1 hp or larger) it is good practice to estimate 1000 W (or 1 kw) of power consumption for each hp output. For fractional hp motors, it is good practice to estimate 1200 W (or 1.2 kw) of power consumption for each horsepower output. For example, a $\frac{1}{4}$ hp motor operating for 2 hours at 300 W per hour would use about 600 W-hours, or about 0.6 kWhrs; and a 2-hp motor operating for 2 hours at 2000 W per hour would use about 4000 W-hours, or 4 kWhrs. Some newer motors are more energy efficient and should be favored.

KILOWATT (kw): Equals 1000 W.

KILOWATT-HOUR (kwhr): A unit of electrical energy. It is the product of power (in kw) and time (in hours). For example, if 2 kw are used for 4 hours, 8 kWhrs of energy will be used; or if 800 W (0.8 kw) are used for 3 hours, 2.4 kWhrs are used. Electrical energy is metered with a kilowatt hour meter and sold by the kwhr.

LIGHTING OUTLET: The wiring device to which various types of fixtures may be fastened.

MOTOR OVERLOAD PROTECTIVE DEVICES: These devices protect the motor against overcurrent caused by overload on the motor. They must be designed and selected so as to trip when the motor current exceeds a safe limit for too long a time, but should have sufficient time-delay to keep them from tripping during the starting period. Generally, the overcurrent protective device is rated or selected to open at not more than 125 percent of the motor full-load current for motors marked to have a temperature rise not over 40°C, and at 115 percent for other types of motors. There are several standard devices that may be used.

NAMEPLATE DATA: The nameplate on a motor gives the approximate amperage (A) the individual motor will use when delivering its rated hp and other valuable information. This A value should be taken into consideration in selecting the wire size for the motor circuit. However, when starting, depending upon the design-type of motor, a motor may take up to 8 times the value of current given on the nameplate. Starting currents should also be taken into consideration when determining the size of circuit, switch, and motor overload protection.

PHASE: Electric power is generally distributed to farms by one of two types of service: single-phase or three-phase. Single-phase is the more common because it is more economical, in most instances. Lighting, appliances and electric motors of 5 hp or smaller are generally designed for single-phase operation. Motors of 10, 15, 20 and up to 50 or more hp can be obtained for single-phase operation on larger equipment. Some of these motors are designed especially for easy starting loads such as centrifugal pumps and large fans. Such motors have relatively low starting currents and operate with good power factor. Use of such motors should be approved by the power supplier.

Occasionally, where a farm or commercial business, in the farm area, uses a large number of motors, with some of large size (over 10 hp), three-phase service may be planned for these motors. Where a limited number of large motors are required, devices called phase-converters may be used to operate three-phase motors from single-phase lines. Approval to use such units should be obtained from the power supplier involved. The decision as to whether to use single-phase or three-phase service is generally determined by the economics involved.

REGULAR FUSE: A fuse containing a single conducting element. This is the familiar, old-style, Edison-base fuse. It is no longer recommended for general use. It is recognized in the NEC only for replacement in existing installations. (NEC 240-51,b)

SERVICE ENTRANCE: The conductors and equipment at the point where electric service enters the building under discussion, including the service entrance wires, circuit breakers or fused switches, and distribution panel. Service equipment must be suitable for short-circuit current, available at its supply terminal.

SPECIAL-PURPOSE OUTLET: A point of connection to the wiring system which, because of its location or type, is usually limited to the particular equipment it is intended to serve. It may be a plug-in receptacle, as in the case of range, crop dryer, portable elevators, clock or laundry outlets; or it may be an outlet box, switch or circuit breaker to which equipment is permanently connected.

THERMAL CUTOUT: This has a time element feature and requires replacement of a solder link after it has opened the circuit because of excessive overload current.

THERMAL PROTECTOR: A device built into the motor and designed to open the motor circuit on excessive overload current or temperature rise.

THERMAL RELAY: This device is usually incorporated into the motor-starting switch and will cause the switch to open when overload current conditions dictate. It has the necessary time-delay feature to allow the motor to start.

TIME-DELAY FUSE: A fuse with the ability to carry overload currents of short duration without melting. The heavier the overload, the less is the time required for the fuse to "blow." In motor circuits, where the starting currents are high but of short duration, this type of fuse need not have as high a rating as a regular fuse to permit the motor to be started. When properly selected and installed so as to carry only the current of a single motor, such fuses can be used to provide motor-running (overload) protection. Like the common fuse, the time-delay fuse is also made in plug and cartridge types. Type S fuses or circuit breakers are required in new construction (NEC 240-51,b).

VOLTAGE DROP: This is the reduction in voltage occurring between power supply and load. This loss occurs whenever electricity flows in wires. It is equal to the product of current and resistance of the circuit wires. For example, if 20 amps of electric current flow through 400 ft. of No. 10 copper wire which has a resistance of 0.64 ohm (), the voltage drop in the wire is: $20 \times 0.64 = 12.8$ V. If 240V are available at the service entrance and 12.8 V are lost in the connecting wires, there will be $240 - 12.8$ or 227.2 V at the point of use. This is loss of $12.8 \div 240 \times 100 = 5.3$ percent. The line loss is equal to the same percent of kw-hr as the percent of voltage drop - in this example, 5.3 percent. In addition to the line loss, voltage drop in the wiring system also results in the loss of light, power and heat, when electrical equipment is operated. A 5 percent voltage loss, for example, results in a 10 percent loss of heat in any heating appliance, or a 17 percent loss of light from an incandescent lamp, or a 10 percent loss in power output of a motor.

VOLT (V): A unit of measure of electrical pressure. A given electrical pressure (V) causes a given amount of electrical current (amperes) to flow through a load of given resistance. The usual pressure or voltage for farm service is 120 V for small appliances and lighting; and 240 V for heating, for 1/2 hp and larger motors and other major appliances.

VOLTAGES: When mentioned as 120 or 240 volts (V) it is understood to be nominal and to include, respectively, voltages of 110 to 120 and 220 to 240.

Single-phase motors are now generally rated either for 115 or 230 volts or both. Three-phase motors are rated for 208, 230 and 460 volts.

Wiring devices such as switches, outlet receptacles, and lamp sockets, are usually rated at 125, 250, or 600 V.

WALL SPACE, FARM RESIDENCE: All portions of a wall, except that occupied by a fireplace opening are considered wall surfaces. The space occupied by sliding panels in exterior walls is considered wall space. Any wall space two feet or greater in length, at the floor, requires a convenience outlet.

WALL SWITCH: A switch which mounts in a device covered by a detachable cover plate. It is not a part of any fixture and is for the control of current to one or more outlets.

WATT (W): A unit of electric power. When applied to utilization equipment, it is the rate of transformation of electrical energy into some other form of energy. The higher the wattage rating, the faster electrical energy is being converted into other forms of energy such as light, heat, or mechanical power. $W = V \times A \times \text{power factor}$. As power factor for incandescent lamps and resistance heaters is equal to 1.0 in these special cases $W = V \times A$. The power factor of the average motor is about 0.8, so for many electric motors, $W = V \times A \times 0.8$.

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 2 - What are the ground-fault circuit-interrupters and how are they applied to farm structures?

Objective: At the conclusion of the lesson, the student will be able to define the use of GFCI's and reference their use in farm structures.

Study Questions:

1. What are GFCI's?
2. What are the NFC requirements for GFCI use?
3. How are GFCI units installed in a farm structure?

References:

1. Agricultural Wiring Handbook, Food and Energy Council, Inc., 909 University Avenue, Columbia, MO 65211.
2. Electrical Safety - Ground-Fault Circuit-Interrupters. UMC-Guide 1023.
3. Planning for Electrical Wiring, VAS-3003b, University of Illinois at Urbana-Champaign, IL

Transparencies:

1. TM #1: The GFCI
2. TM #2: Three Types of GFCI's

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 2 - What are ground-fault circuit-interrupters and how are they applied to farm structures?

TEACHING PROCEDURE

- A. Review the lesson circuit breakers.
- B. Motivation - How much electricity is needed to kill a person? Which substances are good conductors of electricity? Test a GFCI circuit breaker to show how quickly the circuit can be broken.
- C. Assignment - Have the students check their homes for places where GFCI's should be used.
- D. Supervised Study
- E. Discussion

1. Ground-Fault Circuit-Interrupters (GFCI's) are essential in areas where the risk of a shock is high.

What are GFCI's?

- 1) NEC definition
 - a) Ground-Fault Circuit-Interrupter: A device whose function is to interrupt the electric circuit to the load when a fault current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit.
- 2) Function of GFCI See TM #1.
 - a) Interrupt flow of current
 - b) Limit magnitude and time of flow to harmless levels
- 3) Will interrupt flow of 5/1000-amperes in 25/1000 of a second.
- 4) 60/1000-amperes for 1 second or .33-amperes flowing for .33 seconds can be fatal.
- 5) These small amounts will not trip a regular breaker.
- 6) Works by sensing an imbalance between the black and white conductors, an uneven load.
- 7) Faith in a grounding wire in a 3-wire system is not always the best. A faulty ground wire could lead to a lethal charge.

2. The National Electric Code recommends the use of GFCI's in several situations. Where does the class feel they should be used in the home and on the farm?

What are the NEC requirements for GFCI use?

- 1) Homes with 120V, single-phase, 15- and 20-amp duplex outlets
 - a) Installed outdoors
 - b) In garages
 - 2) Optionally protect nonpermanent 15- and 20-amp circuits, i.e., construction.
 - 3) Or use the GFCI's on the feeder circuits (NEC sections 210-8 and 215-9).
 - 4) All receptacles within 15 feet of swimming pools and all equipment used on storable pools. (NEC Sections 680-6 and 680-31).
 - 5) Anywhere where people or livestock can come in contact with electricity and a good ground
 - a) Waterers - livestock and plants
 - b) Outlets in buildings
 - c) Outdoor construction, repair
3. There are three main types of GFCI's available for homes and farms. Each has its uses and portability which need to be considered before selecting the one needed for your situation. See TM #2.

How are GFCI units installed in the farm structure?

- 1) Fixed and permanently installed type
 - a) Substitutes for standard circuit breaker
 - b) Used on feeders
- 2) Plugs into regular duplex receptacle
 - a) Protects only what is plugged directly into it
- 3) Portable with a cord
 - a) Used at construction sites
 - b) Plugs into standard outlets

F. Summary

The GFCI was designed to save lives by detecting even a slight variation in the load between the black and white conductors; then instantaneously shutting off the power.

G. Evaluation

Answers to Exam

1. a. Interrupt flow of current
b. Limit magnitude and time of flow
2. 5, 25
3. F
4. a. Outdoors
b. Bathrooms
c. Garages
5. a. Fixed c. Portable w/cord
b. Plug in

UNIT - ELECTRICAL WORK ON THE FARM

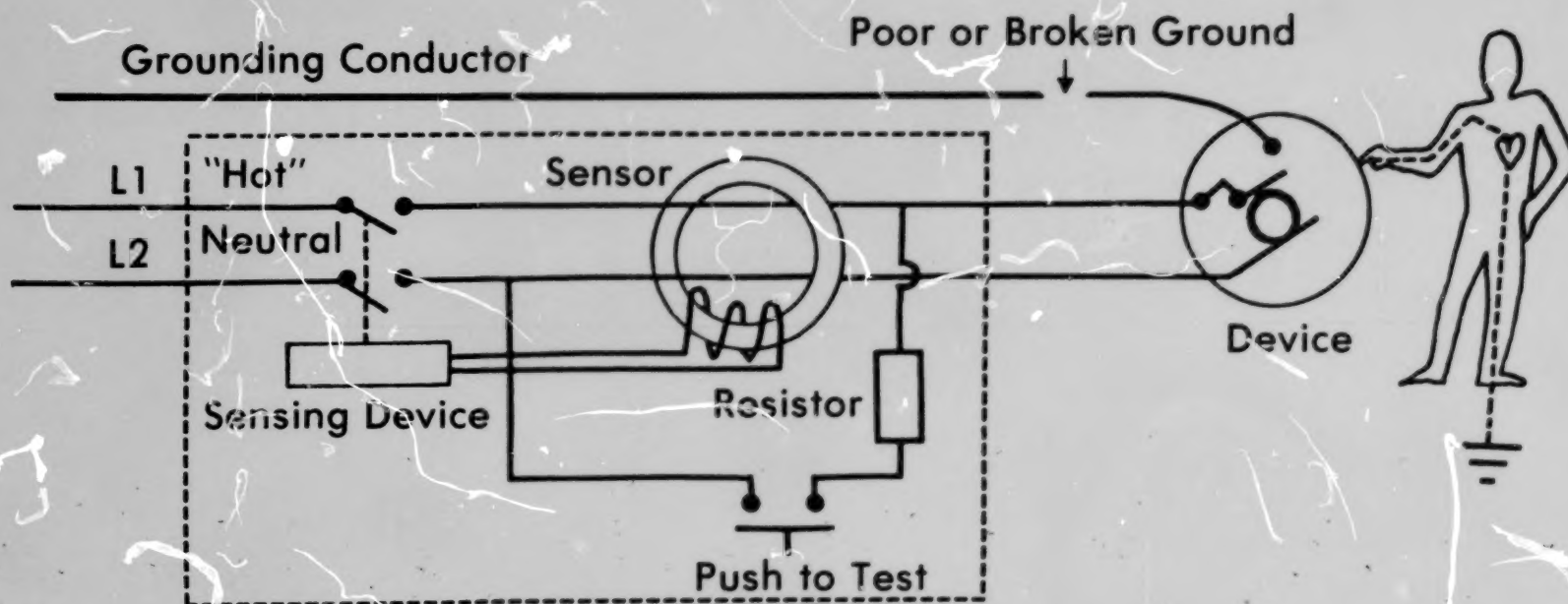
Lesson 2 - What are ground fault circuit interrupters and how are they applied to farm structures?

EXAM

1. Name the two functions of the GFCI.
 - a.
 - b.
2. The GFCI will interrupt a flow of ____/1000-amperes in ____/1000 of a second.
- T F 3. The GFCI works by detecting a difference between the black and ground wires.
4. The NEC requires GFCI's in the home in three locations. What are they?
 - a.
 - b.
 - c.
5. What are the three types of GFCI units.
 - a.
 - b.
 - c.

The GFCI

Ground Fault Circuit Interrupter



309

310

TW-1

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 3 - What are the graphical electrical symbols for farm wiring plans?

Objective: At the conclusion of the lesson, the student will be able to identify the symbols used in farm wiring plans.

Study Questions:

1. Which symbols are used to indicate lighting, receptacle and switch outlets?
2. Which symbols are used to indicate power, fusing and ground?
3. Which symbols are used to indicate panelboards, switchboards and related equipment?
4. Which symbols are used to indicate remote control stations for motors or other equipment?
5. Which symbols are used to indicate miscellaneous connections?

References:

1. Agricultural Wiring Handbook, Food and Energy Council, Inc., 909 University Avenue, Columbia, MO 65211.

Transparencies:

1. TM #1: Electrical Symbols #1
2. TM #2: Electrical Symbols #2

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 3 - What are the graphical electrical symbols for farm wiring plans?

TEACHING PROCEDURE

- A. Review
- B. Motivation - Select one of the plans provided in this lesson and have the class look at the symbols and try to identify them. Then bring into class several outlets to show what each symbol demonstrates in the drawings.
- C. Assignment
- D. Supervised Study
- E. Discussion
 1. The use of symbols is a standardized method of identifying the location of outlets. Familiarity with the symbols is a must for being able to read plans. See TM #1.

Which symbols are used to indicate lighting, receptacle and switch outlets?

- 1) Lighting outlets
 - a) Ceiling - incandescent and fluorescent
 - b) Wall
 - 2) Receptacle outlets
 - a) Single
 - b) Double
 - c) Triple
 - d) Range
 - e) Clock
 - 3) Switch outlets
 - a) Single-pole (SPST)
 - b) Double-pole (DPST)
 - c) Three-way (SPDT)
 - d) Four-way (DPDT)
 - e) Switch w/pilot
 - f) Switch w/receptacle
 - g) Door
 - h) Time
 - i) Ceiling pull
2. In each diagram there is also a need to identify motors, fuses and grounding locations. These each have distinctive symbols and are important to agriculture.

Which symbols are used to indicate power, fusing and ground?

- 1) Electric motor
- 2) Electric generator
- 3) Transformer
- 4) Meter
- 5) Circuit breaker
- 6) Fusible element
- 7) Ground

3. Wall panels are important when controlling several pieces of equipment simultaneously. They need to be located in centralized locations.

Which symbols are used to indicate panelboards, switchboards and related equipment?

- 1) Surface mounted
- 2) Power controller
- 3) Externally operated disconnection switch
- 4) Combination controller and disconnection switch

4. The use of remote control devices is essential for reducing labor in farming situations. Where are they used in your community?

Which symbols are used to indicate remote control stations for motors or other equipment?

- 1) Push button
- 2) Float switch-mechanical
- 3) Limit switch-mechanical
- 4) Pneumatic switch-mechanical
- 5) Thermostat

5. There are other symbols used to indicate specific types of electrical connections.

Which symbols are used to indicate miscellaneous connections?

- 1) Special identification of outlets
 - a) WP - Weather Proof
 - b) VT - Vapor Tight
 - c) WT - Water Tight
 - d) RT - Rain Tight
 - e) DT - Dust Tight
 - f) EP - Explosion Proof
 - g) G - Grounded
 - h) R - Recessed
- 2) Other symbols for specific purposes. See TM #2.
 - a) Resistors
 - b) Capacitors

- c) Time delay
- d) Diode
- e) Transistor

F. Summary

The use of standardized symbols is an important part of any instructional unit in structures or basic electricity. A thorough understanding is important to achieve wiring success.

G. Evaluation

Answers to Exam

- 1. g
- 2. i
- 3. e
- 4. c
- 5. j
- 6. a
- 7. b
- 8. d
- 9. h
- 10. f

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 3 - What are the graphical electrical symbols for farm wiring plans?

EXAM

Directions: Match the symbol with the terms in the opposite column.

- ____ 1. 
- ____ 2. 
- ____ 3. 
- ____ 4. 
- ____ 5. 
- ____ 6. 
- ____ 7. 
- ____ 8. 
- ____ 9. 
- ____ 10. 

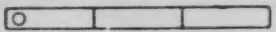
- a. Ground
- b. Power controller
- c. Switch w/pilot
- d. Thermostat
- e. Single-pole switch
- f. Fusible element
- g. Surface lighting outlet
- h. Vapor tight
- i. Duplex receptacle
- j. Motor connection

Electrical Symbols

1.0 Lighting Outlets Ceiling

1.1  Surface or pendant incandescent or similar lamp fixture

1.3  Surface or pendant individual fluorescent fixture

1.5  Surface or pendant continuous row fluorescent fixture

1.10  Blanked outlet

1.11  Junction box

Wall

 To indicate wall installation of above outlets, place circle near wall and connect with line as shown

2.0 Receptacle Outlets

2.1  Single receptacle outlet

2.2  Duplex receptacle outlet

2.3  Triplex receptacle outlet

2.5  Duplex receptacle outlet - Split wired

2.7  Single special-purpose receptacle outlet

2.8  Duplex special purpose receptacle outlet

2.9  Range outlet

2.12  Clock hanger receptacle

3.0 Switch Outlets

3.1  Single pole switch (SPST)

3.2  Double pole switch (DPST)

3.3  Three-way switch (SPDT)

3.4  Four-way switch (DPDT)

3.6  Switch and pilot lamp

3.9  Switch and single receptacle

3.10  Switch and double receptacle

3.11  Door switch

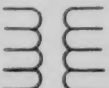
3.12  Time switch

3.15  Ceiling pull switch

Power, Fusing, Ground

(46.3)  Electric motor

(46.2)  Electric generator

(86.1)  Power transformer

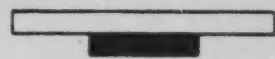
(48)  Electric watthour meter

(11.1)  Circuit breaker

(36)  Fusible element

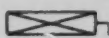
(13.1)  Ground

6.0 Panelboards, Switchboards and Related Equipment

6.2  Surface-mounted panelboard and cabinet

6.7  Motor or other power controller*

6.8  Externally operated disconnection switch

6.9  Combination controller and disconnection means

8.0 Remote Control Stations for Motors or Other Equipment

8.1  Pushbutton station

8.2  Float switch - Mechanical

8.3  Limit switch - Mechanical

8.4  Pneumatic switch - Mechanical

8.5  Thermostat

Low-Voltage and Remote-Control Switching Systems

1.12  Outlet controlled by low-voltage switching when relay is installed in outlet box

3.7  Switch for low voltage switching system

3.8  Master switch for low voltage switching system

TM-1

Electrical Symbols

TM-2

1		Resistor	21		Time delay closing, N.O.
2		Variable resistor	22		Time delay opening, N.O.
3		Potentiometer	23		Time delay closing, N.C.
4		Capacitor	24		N.O. relay contacts
5		Coil or inductor	25		N.C. relay contacts
6		Grounded terminal	26		SPDT relay contacts
7		Battery	27		Make-before-break SPDT relay contacts
8		Connection	28		DPDT relay contacts
9		No connection	29		Thermostat
10		Thermo-mechanical transducer	30		Thermal time delay relay, N.O. contacts
11		Normally open (N.O.), pushbutton switch	31		Overload protector with N.C. contacts
12		Normally closed (N.C.), pushbutton switch	32		Auto-transformer, adjustable
13		Single pole, double-throw pushbutton switch	33		Isolation transformer
14		Single pole, single-throw switch	34		Motor
15		Single-pole, double-throw switch (SPDT)	35		Diode
16 a		Circuit breaker	36		Zener diode
b		Fuse or fusible element	37		SCR
17		Selector switches	38		Triac
18		N.O. limit switch	39		PNP transistor
19		N.C. limit switch	40		NPN transistor
20		Time delay opening, N.C.			

Special Identification of Outlets: Supplemental Symbol Schedule

WP	Weather proof	DT	Dust tight
VT	Vapor tight	EP	Explosion proof
WT	Water tight	G	Grounded
RT	Rain tight	R	Recessed

319

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 4 - Identifying wire types and sizes used in farm wiring.

Objective: By the end of the lesson, the student will be able to match the type of wire with its use.

Study Questions:

1. What are the different types of wire?
2. Why is wire size important?
3. How do you select the right wire size?
4. Which wires are best adopted for farm wiring?

References:

1. National Electrical Code 1978, NECA.
2. Wiring Simplified, H.P. Richter. Park Publications Inc., 1999 Shepard Road, St. Paul, MN 55116. Available through IML, UMC.
3. Practical Farm Wiring Demonstrations, by Curtis Weston. Editions I or II.

Handouts:

1. HO #1: Copper and Aluminum Loads and Sizes, Weights and Resistances of Conductors
2. HO #2: Loss Evaluation and Wire-Size Selection Chart

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 4 - Identifying wire types and sizes used in farm wiring.

TEACHING PROCEDURE

- A. Review basic electrical movement before talking about electric flow through wires.
- B. Motivation - Have you ever plugged in an appliance and seen the lights dim? This is caused by too many appliances on one electrical conductor.
- C. Assignment
- D. Supervised Study - Use the electrical board to demonstrate voltage drop in relation to wire size and type. Practical Farm Wiring Demonstrations, Sections I: G, H, I.
- E. Discussion
 1. In order to receive electricity at the farm building, the power must flow through a series of different sizes and types of wire. Each type is identifiable by its components and lettering scheme.

What are the different types of wire?

- 1) SE - this wire is used to connect the service entrance.
- 2) USE - this wire is used underground to connect to the service entrance.
- 3) UF - underground feeder wire used as a branch circuit.
- 4) T - a single layer of plastic compound in a single wire, may be stranded.
- 5) TW - same as T only moisture and heat resistant.
- 6) THW - same as T only moisture and heat resistant.
- 7) RH - rubber compound either natural or synthetic followed by an outer fabric braid that is saturated in moisture and fire retardant compounds.
- 8) RHH - heat resistant
- 9) RHW - heat and water resistant
- 10) NM - nonmetallic sheathed cable with 2 or more type T wires - dry locations.
- 11) NMC - same as NM but for outdoors, damp and corrosive situations.
- 12) SPT - lamp cord, small extension cords.
- 13) S or SJ - rubber covered like motor cord.
- 14) HPD - toaster, skillets with asbestos covered wire plus a braid of cotton.

- 15) Ground wire - for number 2 or smaller service use number 8 wire.
 - a) For number 1 or 0 service, use number 6 ground wire.
 - b) For number 2/0 or 3/0 service use number 4 ground wire.
 - 16) Armoured cable - with type T or TW wires wrapped in paper.
 - 17) Aluminum wire - Aluminum is a relatively poor conductor; a larger size must be used than when using copper. A rule of thumb is to use aluminum wire 2 sizes heavier than the needed copper wire.
2. Wire size is as important as the wire type when planning a wiring system. The larger the wire the more load that can be carried SAFELY. Use HO #1 and #2.

Why is wire size important?

- 1) Copper wire sizes are indicated by number.
 - a) Number 14 size is the smallest allowed in most construction and ranges to 4/0 size which is 1/2 inch in diameter.
 - b) Size 16 and 18 are much smaller wires and have limited use in farm wiring.
 - c) They are used in motor windings and thermostat controls which operate at less than 30 volts.
- 2) There are two important reasons for selecting the correct wire size: ampacity and voltage drop.
 - a) Ampacity is the flow of electricity in the wire which creates heat. Doubling the amperes without changing the wire size increases the heat output four times.
 - b) Voltage drop is the loss of pressure over a run of wire, also affected by wire size.
- 3) Wire size is dependent upon the load to be carried in watts, volts and amps. Once the load has been calculated refer to the NEC Book for wire size or page 24 of Wiring Simplified.
 Example: Using type UF cable buried, at 40 amps, 240 volts requires size 6 wire. Using Ohms law $A \times V = W$, $40 \times 240 = 9600$ watts. This would be the maximum power.
- 4) By forcing too many amperes through a wire that is too small, we get voltage drop.
 - a) Voltage drop is wasted power. Another point is that machinery run at these lower voltages works very inefficiently.
 - b) At 90% of rated voltage, a motor produces only 81% of normal power; a lamp produces only 70% of its normal light.

- c) A voltage drop of 2% over a 100-foot run of wire is acceptable, but more is wasteful.
3. After the loads are established in each circuit, the proper wire size must be determined. The Electric Code provides tables for this purpose. Wright has also developed a table for general use. Use H0 #4 in Lesson 8.

How do you select the right size wire?

- 1) For farm use, wire should not be smaller than size 12. For ease in calculation, tables have been developed to aid in this matter. Before they can be used you must know:
 - a) Type of wire - open air, buried, etc.
 - b) Amperage load
 - c) Voltage
 - d) Wattage
 - e) Length of run - remember you need 2 wires so a motor 200 feet away needs 400 feet of wire. The tables have been corrected to one-way travel.
- 2) Use 240 volts whenever possible because for any size of wire 240 volts will carry the same amperage twice as far as a 120 volts. With the same percentage voltage drop, it will carry the same number of watts four times as far.
 - a) Example: 30-amperes at 120 volts is 3600 watts; wire run 150 feet one way requires a number 4 wire.
 - b) Example: 30-amperes and 240 volts is 7200 watts; wire run 150 feet one way requires number 6 wire.

NOTE: If the run falls between two sizes, always use the larger wire (the lower number).
- 3) When running overhead wires be sure the wires are large enough to support the weight. NEC sets the following minimums:
 - a) For 600 volts or less, number 10 for spans up to 50 feet in length and number 8 for longer spans.
 - b) For over 600 volts, number 6 where open individual conductors and number 8 where in a cable.
 - c) For distances over 150 feet it would be wise to use an extra pole especially in ice-prone areas.
4. The requirements for farm buildings are slightly different from home or business electrical work. The Electric Code in Article 547 sets the criteria.

Which wires are best adapted to farm wiring?

- 1) The Electric Code sets provisions that shall apply to the following agricultural buildings:
 - a) Agricultural buildings where excessive dust and dust with water may accumulate - Such buildings include all areas of totally enclosed and environmentally controlled poultry and livestock confinement systems, where litter, dust, and feed dust, including mineral feed particles, may accumulate and enclosed areas of similar or like nature.
 - b) Agricultural buildings where a corrosive atmosphere exists - Such buildings include totally enclosed and environmentally controlled areas where (1) poultry and animal excrement may cause corrosive vapors in the confinement area; (2) corrosive particles may combine with water; (3) the area is damp and wet by reason of periodic washing for cleansing and sanitizing with water and cleansing agents; (4) similar conditions exist.
- 2) The types of wire approved for agricultural buildings are UF, NMC, SNM, and other cables or raceways that are highly resistant to corrosion. The wires and fixtures must be "dust-ignition-proof" which means that no arcs, sparks or heat sufficient to cause ignition of dust shall be used.

F. Summary

G. Evaluation

Answers to Exam

1. b
2. e
3. g
4. c
5. a
6. d
7. f

324

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 4 - Identifying wire types and sizes used in farm wiring.

EXAM

Match the terms and definitions.

- | | |
|--------------|-------------------------------------|
| _____ 1. SE | a. Dry condition, nonmetallic |
| _____ 2. UF | b. Used to connect service entrance |
| _____ 3. T | c. Moisture and heat resistant |
| _____ 4. THW | d. Nonmetallic outdoors |
| _____ 5. NM | e. Underground feeder |
| _____ 6. NMC | f. Lamp cord |
| _____ 7. SPT | g. Single layer of plastic |

Copper and Aluminum Loads

HO-1

Material	Load (Amperes)	Voltage	Phase	Voltage Drop
10 Copper	200	115-120	Single	2%
11 Aluminum	200	115-120	Single	2%
12 Copper	200	115-120	Single	3%
13 Aluminum	200	115-120	Single	3%
14 Copper	200	115-120	Single	4%
15 Aluminum	200	115-120	Single	4%
16 Copper	400	230-240	Single	2%
17 Aluminum	400	230-240	Single	2%
18 Copper	400	230-240	Single	3%
19 Aluminum	400	230-240	Single	3%
20 Copper	400	230-240	Single	4%
21 Aluminum	400	230-240	Single	4%
22 Copper	400	480	Single	2%
23 Aluminum	400	480	Single	2%
24 Copper	400	480	Single	3%
25 Aluminum	400	480	Single	3%
26 Copper	400	480	Single	4%
27 Aluminum	400	480	Single	4%
28 Copper	400	230-240	Three	2%
29 Aluminum	400	230-240	Three	2%
30 Copper	400	230-240	Three	3%
31 Aluminum	400	230-240	Three	3%
32 Copper	400	230-240	Three	4%
33 Aluminum	400	230-240	Three	4%
34 Copper	400	480	Three	2%
35 Aluminum	400	480	Three	2%
36 Copper	400	480	Three	3%
37 Aluminum	400	480	Three	3%
38 Copper	400	480	Three	4%
39 Aluminum	400	480	Three	4%

Sizes, Weights and Resistances of Conductors

Size AWG or MCM	Circular Mils	Copper		Aluminum	
		Weight per 1000 ft.	Resistance ohms per 1000 ft.	Weight per 1000 ft.	Resistance ohms per 1000 ft.
12	6530	19.8	1.59	6.01	2.57
10	10380	31.43	0.9988	9.556	1.62
8	16510	49.98	0.6281	15.20	1.02
6	26240	79.44	0.3952	24.15	0.6395
4	41740	126.3	0.2485	38.41	0.4021
3	52620	159.3	0.1971	48.43	0.3189
2	66360	205	0.1594	62.3	0.2580
1	83690	259	0.1264	78.6	0.2045
0	105600	326	0.1002	99.1	0.1622
00	133100	411	0.07949	125	0.1286
000	167800	518	0.06306	157	0.1020
0000	211600	653	0.04999	199	0.0809
250	250000	772	0.04232	235	0.06847
300	300000	925	0.03526	282	0.05706
350	350000	1080	0.03022	328	0.04891
400	400000	1236	0.02645	375	0.04280
500	500000	1542	0.02115	469	0.03423
600	600000	1850	0.01764	563	0.02853
700	700000	2160	0.01512	657	0.02445
750	750000	2316	0.01411	704	0.02283
800	800000	2469	0.01322	751	0.02140
900	900000	2780	0.01175	845	0.01902
1000	1000000	3086	0.01058	938	0.01712

Loss Evaluation

HO-2

(Based on 500 hours use of load electricity at 2¢ per kwhr)														
Wire Size	Distance (Ft.)	ELECTRICAL LOAD—AMPERES												
		5	10	15	20	25	30	35	40	50	60	70	80	90
#14	50	\$0.10	\$0.26	\$0.60										
	100	0.19	0.52	1.20										
	200	0.38	1.04	2.40										
	300	0.57	1.56	3.60										
BEYOND THE ALLOWABLE														
#12	50	0.06	0.16	0.36	\$0.64									
	100	0.12	0.32	0.72	1.28									
	200	0.24	0.64	1.44	2.56									
	300	0.36	0.96	2.16	3.84									
CURRENT CARRYING														
#10	50	0.04	0.10	0.22	0.40	\$0.62	\$0.90							
	100	0.08	0.20	0.45	0.80	1.24	1.80							
	200	0.16	0.40	0.90	1.60	2.48	2.70							
	300	0.24	0.60	1.35	2.40	3.72	5.40							
CAPACITY OF														
#8	50	0.03	0.06	0.15	0.25	0.40	0.60	\$0.77	\$1.02					
	100	0.05	0.12	0.30	0.50	0.80	1.20	1.54	2.04					
	200	0.09	0.24	0.60	1.00	1.60	2.40	3.08	4.08					
	300	0.14	0.36	0.90	1.50	2.40	3.60	4.62	6.12					
INSULATED														
#6	50	0.02	0.04	0.09	0.16	0.25	0.36	0.49	0.64	\$1.00				
	100	0.03	0.08	0.18	0.32	0.50	0.72	0.98	1.28	2.00				
	200	0.06	0.16	0.36	0.64	1.00	1.44	1.76	2.56	4.00				
	300	0.09	0.24	0.54	0.96	1.50	2.16	2.64	3.84	6.00				
WIRE														
#4	50	0.01	0.03	0.06	0.08	0.15	0.22	0.32	0.40	0.62	\$0.90	\$1.22		
	100	0.02	0.05	0.12	0.16	0.30	0.44	0.64	0.80	1.24	1.80	2.44		
	200	0.04	0.10	0.24	0.32	0.60	0.88	1.28	1.60	2.48	3.60	4.88		
	300	0.05	0.15	0.36	0.48	0.90	1.32	1.92	2.40	3.72	5.40	7.32		
#2	50		0.02	0.04	0.06	0.10	0.13	0.18	0.24	0.40	0.60	0.77	\$1.00	\$1.26
	100	0.01	0.03	0.07	0.12	0.20	0.25	0.36	0.48	0.80	1.20	1.54	2.00	2.52
	200	0.02	0.06	0.14	0.24	0.40	0.50	0.72	0.95	1.60	2.40	3.08	4.00	5.04
	300	0.04	0.10	0.21	0.36	0.60	0.75	1.08	1.44	2.40	3.60	4.62	6.00	7.56

To Determine Most Economical Wire Size

(Cost of Wire)

Annual Costs = $\frac{\text{Cost of Wire}}{15}$ + Costs of Kwh Lost

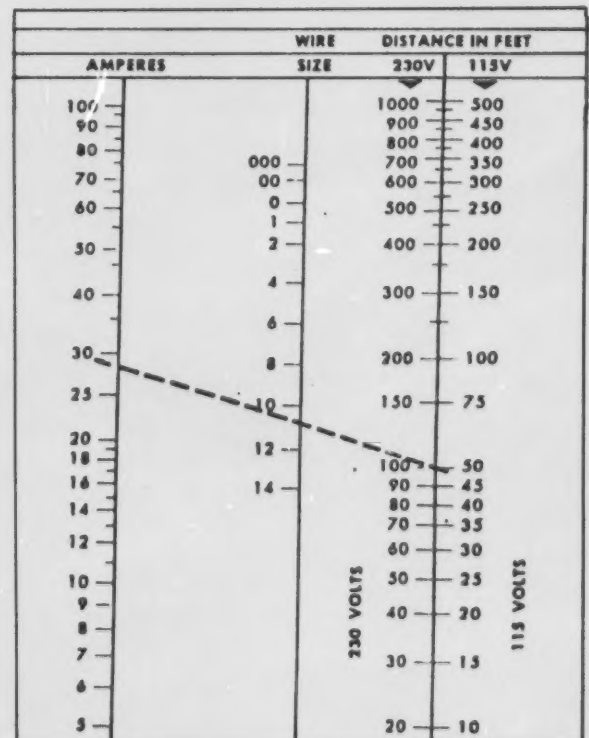
*NOTE: With increasing energy and labor costs, tabulated data are relative, not absolute.

Note: 1. Wire cost to include complete 2 or 3 wire circuit;

2. Labor, maintenance and taxes assumed the same for all sizes;

3. Average life of wiring assumed—15 years.

Wire-Size Selection Chart



UNIT - ELECTRICAL WORK ON THE FARM

Lesson 5 - What are the general requirements to consider when constructing a farm structure?

Objectives: At the conclusion of the lesson, the student will be able to locate lights, outlets and switches; and identify protection needs in farm structures.

Study Questions:

1. What are the rules for lighting outlets located in a farm structure?
2. What are the rules for convenience outlets located in a farm structure?
3. What are the rules for switches located in a farm structure?
4. What electrical protection is needed in a farm structure?
5. What are the general recommendations for branch circuits?

Reference:

1. Agricultural Wiring Handbook, Food and Energy Council, Inc., 909 University Avenue, Columbia, MO 65211.

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 5 - What are the general requirements to consider when constructing a farm structure?

TEACHING PROCEDURE

- A. Review the terms used in electricity.
- B. Motivation - How high should switches and outlets be placed above the floor? Is there a danger of electrocution in animals from low outlets? What causes dust explosions in barns?
- C. Assignment
- D. Supervised Study
- E. Disucssion

1. The first thing to remember before installing new wiring is to install the following applicable safety standards of both National Electric Code and local rules and regulations. Information is easily available from local power suppliers or extension personnel.

What are the rules for lighting outlets located in a farm structure?

- 1) Wet areas use nonmetallic receptacles.
 - a) Porcelain
 - b) Plastic
 - c) Rubber
- 2) Use dust-tight lights in dusty areas.
 - a) Feed grinding
 - b) Feed storage
 - c) Hay storage
- 3) Match the outlets to the environmental conditions.

2. Planning to include a sufficient number of convenience outlets is a must in a modern farm structure.

What are the rules for convenience outlets located in a farm structure?

- 1) Locate as high as possible but can be conveniently reached
- 2) Mount between studding or flush with wall.
- 3) All outlets must be 20-amp duplex outlets w/safety ground.
- 4) Drop cords are usable in most situations.

- 5) Cord types SJ, SJO, SO, ST for hard use in damp areas, sizes up to number 10
 - 6) In living spaces locate outlets 12 inches above floor line.
3. The location of switches is important in a farm structure especially one with multiple doors. They need protection from the elements as well as being convenient to the user.

What are the rules for switches located in a farm structure?

- 1) Locate the switches
 - a) At latch side of door
 - b) On traffic side of arches
 - c) Within room to be controlled except for outside lighting, closets, etc.
 - 2) Multiple-switch control in areas of high use with many doors
 - a) Rule of thumb - switch if doors over 10 feet apart
4. There needs to be circuit protection included in every electrical plan. These come in many forms.

What electrical protection is needed in a farm structure?

- 1) Branch circuits should not exceed 2 percent voltage drop or be smaller than number 12 AWG.
 - 2) For feeders and branch circuits not over 5 percent drop total.
 - 3) Make provisions for grounding all noncurrent carrying metal parts.
 - 4) If UF, NMC or similar cable with nonmetallic sheath is used, include a ground wire of the same size as current carrying wires.
 - 5) Each branch circuit needs fuse or breaker protection.
 - 6) Base protection on capacity of the wires
5. Branch circuit planning is the key to efficient energy management in the planning of farm wiring. What is a branch circuit? Where are they used?

What are the general recommendations for branch circuits?

- 1) Number 12 AWG wire is the minimum recommended size.
- 2) General purpose circuit includes:

- a) Permanent lighting
- b) Convenience outlets - portable equipment
- c) Special lighting - UV, bacterial
- d) Portable heaters, 1500W or less
- 3) Limitations
 - a) Load not to exceed 80 percent or branch rating
 - b) Fixed appliances not over 50 percent if lighting also provided on circuit
 - c) For unknown loads estimate 1.5-amps per outlet.
- 4) Individual branch circuits need protection if service is:
 - a) 1/2-hp motor or larger
 - b) Stationary appliance over 1500W
 - c) Continuous service appliance
 - d) All 240V appliances

F. Summary

The location of all types of outlets is important to the safety of the people and animals as well as convenient to the workers. Prior planning and the use of common sense will make working in new structures much easier.

G. Evaluation

Answers to Exam

- 1. a. porcelain
b. rubber
c. plastic
- 2. 20-amps duplex receptacle w/safety ground
- 3. Number 12 AWG
- 4. 2%
- 5. T

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 5 - What are the general requirements to consider when constructing a farm structure?

EXAM

1. List two nonmetallic receptacles.

a.

b.

2. All convenience outlets in a farm structure must be:

3. The minimum size wire for a branch circuit is:

4. Maximum voltage drop in a branch circuit is _____.

T F 5. Individual circuit protection is needed if an appliance needs over 240 volts.

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 6 - What are the factors to consider when planning the electrical needs of farm structures?

Objective - At the conclusion of the lesson, the student will be able to plan the electrical needs of various farm structures.

Study Questions:

1. What are the factors to consider when planning dairy structures?
2. What are the factors to consider when planning beef structures?
3. What are the factors to consider when planning hog farming?
4. What are the factors to consider when planning hog finishing structures?
5. What are the factors to consider when planning farm shop structures?
6. Where and when are ground-fault circuit-interrupters used in farm structures?

References:

1. Agricultural Wiring Handbook, Food and Energy Council, Inc., 909 University Ave., Columbia, Mo. 65211

Transparencies:

1. TM #1: Dairy Needs
2. TM #2: Hog Needs
3. TM #3: Farm Shop Needs

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 6 - What are the factors to consider when planning the electrical needs of farm structures?

TEACHING PROCEDURE

- A. Review electrical terms and symbols.
- B. Motivation - Who can read a building plan and identify all the symbols? What determines where they are placed in the diagram? How many of each outlet should we have in a farm structure?
- C. Assignment - Locate the outlets in one of the farm buildings on your farm and complete a wiring diagram. Check how far apart each is and how far each is from floor level.
- D. Supervised Study
- E. Discussion
 1. Each type of structure has unique building needs. In the area of electric needs dairy has more need for specialized connections for high draw equipment. See TM #1.

What are the factors to consider when planning dairy structures?

- 1) Power needs
 - a) Lighting
 - b) Space heating
 - c) Water heating
 - d) Portable tools
 - e) Special devices
 - f) Electric motors
 - g) Refrigeration
 - h) Pumps
- 2) Plan ahead to conveniently locate equipment.
- 3) Lighting
 - a) 12 feet apart (1.5 times lamp mounting height)
 - b) Switches for maximum convenience
- 4) Duplex receptacles
 - a) About 20 feet on center, every place reachable with 25 foot extension cord
 - b) Six feet above floor
- 5) Special purpose outlets for 120V or 240V with varying amperages (Check with tables for sizes.)

2. Beef cattle structures do not require as much electricity as dairy but they do have needs dependent on weather and feeding conditions.

What are the factors to consider when planning beef structures?

- 1) Lighting outlet for every 400 square feet of open area w/wall switch
- 2) In feed alleys light outlets every 20 to 25 feet on center of alley
- 3) Photo electric switch can be used for all night feeding.
- 4) Locate 20-amp outlets at locations where clippers, immersion heaters, etc., will be used.
- 5) Special branch outlets for feed motors, heating cables for waterers
- 6) Special circuits for heated stock water's and waste management equipment
- 7) Use GFCI's on water circuits.

3. Electrical needs in hog facility will depend on the type of facility. The farrowing house will need more service than a finishing floor. Use TM #2.

What are the factors to consider when planning hog farrowing structures?

- 1) Lighting outlets
 - a) One outlet per two farrowing crates located over partition if single row controlled from door
 - b) One outlet every 12 to 15 feet if double or triple rows
 - c) For pens, one light outlet for every three sows
- 2) Convenience outlets
 - a) One duplex outlet per pen, 20-amp
 - b) If several heat lamps are used, install a 3-wire 120/240V circuit with alternate outlets connected on opposite sides of circuit for better load balance.
- 3) Special-purpose outlets
 - a) Ventilator fans
 - b) Floor heat cables (20-amp 3500 watts on 240V or 1750 watts on 120V)
 - c) Locate thermostats and thermostat wires in diagram.
 - d) Water heater
 - e) Water pump
 - f) Feed motors
 - g) Pit cleaning

335

4. The finishing hog building is more open and requires less specialized wiring. Be careful not to plan for too few circuits. See TM #2.

What are the factors to consider when planning hog finishing structures?

- 1) Lighting outlets
 - a) One for each pair of pens or every 150 square feet of pen area
 - b) With aisle light every 12 to 15 feet along aisle and row of lights over each pen row
 - c) Use a switch for each row of lights.
 - d) Use 3-way switches if several doors are in building.
- 2) Convenience outlets
 - a) 20-amp duplex outlet every 15 to 20 feet in alleyways
 - b) Place 5 to 6 feet above floor level.
 - c) Or hang from ceiling
- 3) Special-purpose outlets
 - a) 20-amp circuits for ventilator fans, use several circuits so in case of failure in one, others will continue to operate.
 - b) Feed motors 120/240V
 - c) Waste handling 120/240V
 - d) Electric heaters 240V

5. An essential part to any farm is the farm shop. Here most of the heavy repair and maintenance is performed, requiring heavy electrical needs for time-saving equipment. See TM #3.

What are the factors to consider when planning farm shop structures?

- 1) General lighting
 - a) 10 to 12 feet on center and 4 to 6 feet from walls or
 - b) One outlet per 100 to 150 square feet
 - c) Separate switch for each row of lights
- 2) Local lighting
 - a) Two outlets over each 10 feet of work bench w/wall switch or
 - b) Two 150 W reflector bulbs 50 inches above bench or
 - c) Use fluorescent above front 1/2 of bench
- 3) Outside use mercury vapor with photo cell control
- 4) Convenience outlets
 - a) One 20-amp duplex for each 4 feet of work-bench
 - b) One outlet at each permanent location of motor driven tool of 1/2-horsepower or less
 - c) One extra outlet on each wall of shop

- d) Place 48 inches above floor.
- e) Place wires in conduit if within 8 feet of floor.
- 5) Special-purpose outlets
 - a) Individual branch circuits for each motor over 1/2-horsepower
 - b) Design so one circuit will serve no more than:
 - i) Three 1/3-hp motors or
 - ii) Two 1/2-hp motors or
 - iii) One 1-hp motor
 - c) Plan for 50-amp, 240V, 2-wire with ground circuit and outlet for welder
 - d) Circuits for space heating
- 6. Electrocution is a problem on farms whether it is a human or animal. Electrocution occurs as a result of a fatal electric charge. This problem led to the development of a GFCI that will shut down a circuit should a piece of equipment malfunction.

When and where are ground-fault circuit-interrupters used in farm structures?

- 1) The National Electric Code recommends GFCI's for 15- to 20-amp duplex outlets when located:
 - a) Outdoors
 - b) In bathrooms
 - c) In garages
- 2) The GFCI reacts by instantaneously severing power when only a slight change in load is determined in the circuit.
- 3) Will trip when a flow of 5/1000-amperes for 25/1000 of a second is detected in the circuit.
- 4) Compare to a breaker or fuse, flow of 60/1000-amperes for 1 second can be fatal and this amount may not trip a conventional system.
- 5) Three types of GFCI's are available.
 - a) Fixed or permanently installed in breaker box
 - b) Direct plug into regular receptacle
 - c) Portable with a cord which plugs into regular receptacle

F. Summary

The electrical needs of a building will depend on the type of livestock and the amount of work to take place within the structure. Prior planning and the development of good working plans will facilitate installation and provide time to plan convenience items.

Be sure to include GFCI's whenever possible to protect against electrocution.

G. Evaluation

Answers to Exam

1. F
2. T
3. T
4. b
5. c
6. e
7. d
8. a

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 6 - What are the factors to consider when planning the electrical needs of farm structures?

EXAM

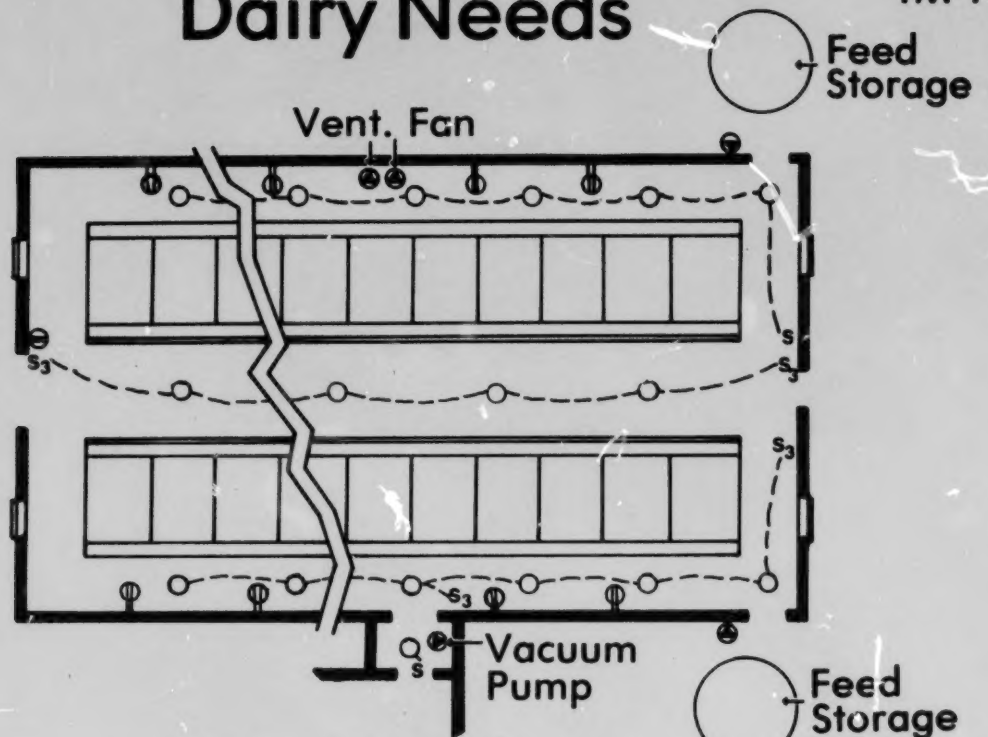
- T F 1. The lighting in a farm structure is the same no matter which type of livestock is housed within.
- T F 2. Dairy building will usually require more electricity than other animal housing units.
- T F 3. The location of duplex receptacles should be high enough to prevent contact with animals.

Match the following items

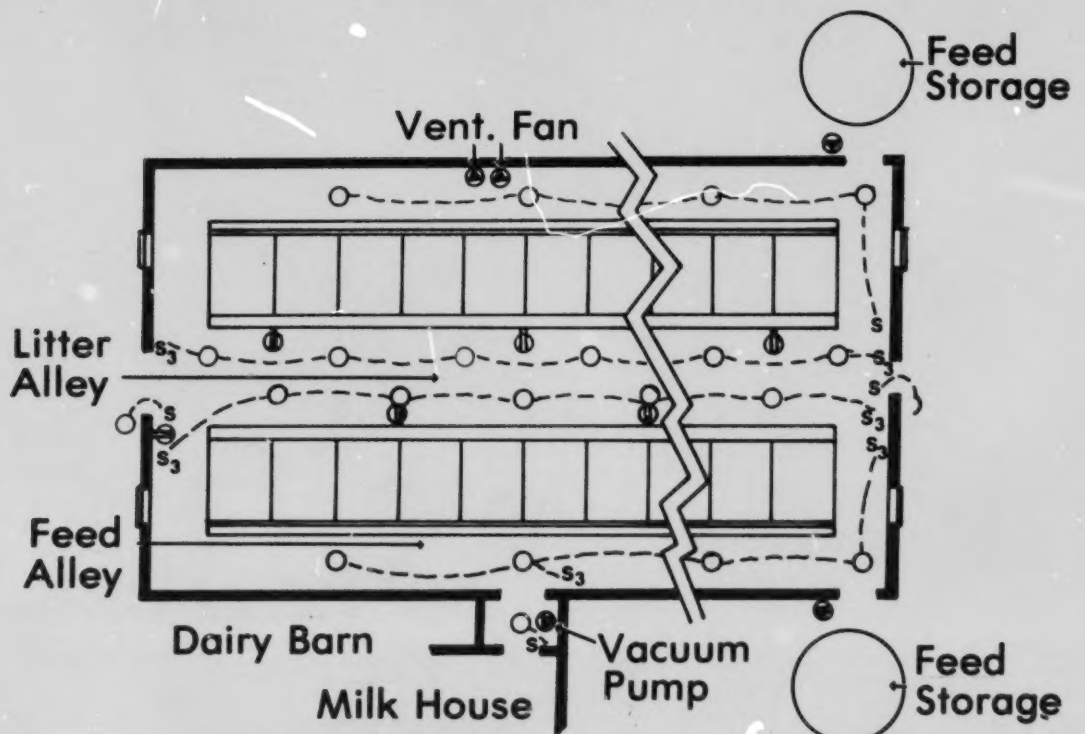
- | | |
|-------------------------------|------------------------------------|
| ___ 4. Photoelectric switch | a. Used outdoors |
| ___ 5. Special branch circuit | b. Mercury vapor night lights |
| ___ 6. Lighting | c. Welder |
| ___ 7. Ventilator fans | d. Individual circuits |
| ___ 8. GFCI's | e. Provide switch at each entrance |

Dairy Needs

TM-1



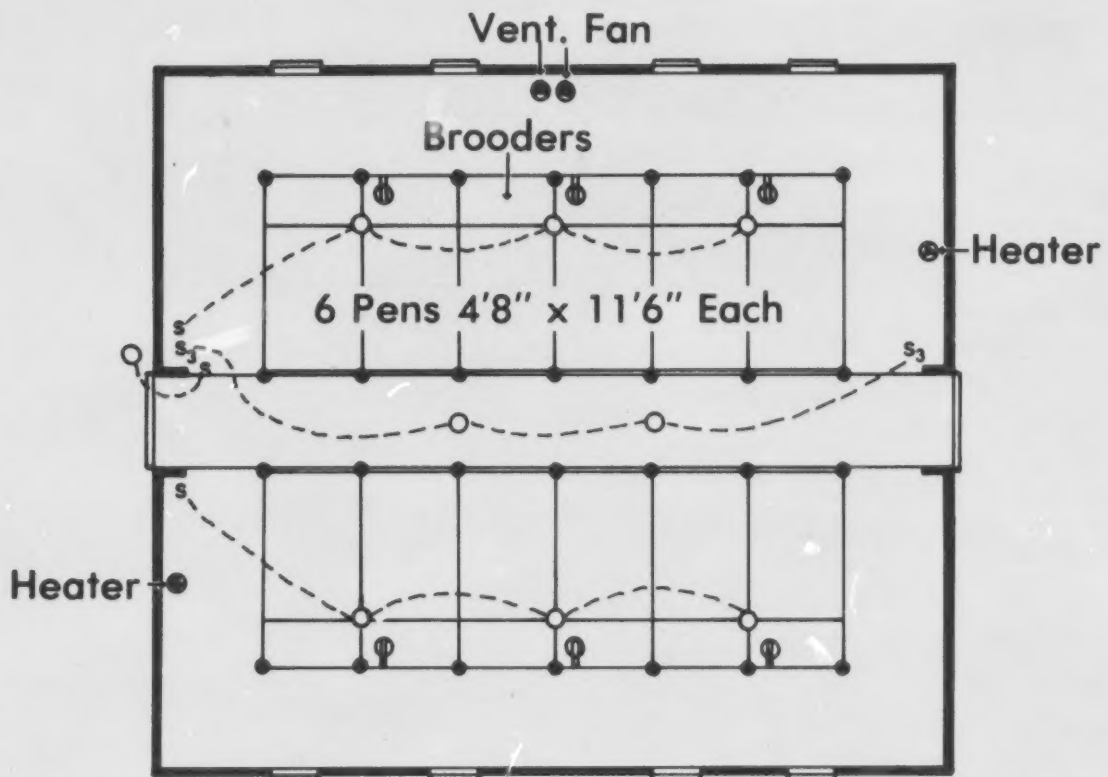
Lighting For Stanchion Barn,
Face-In Arrangement



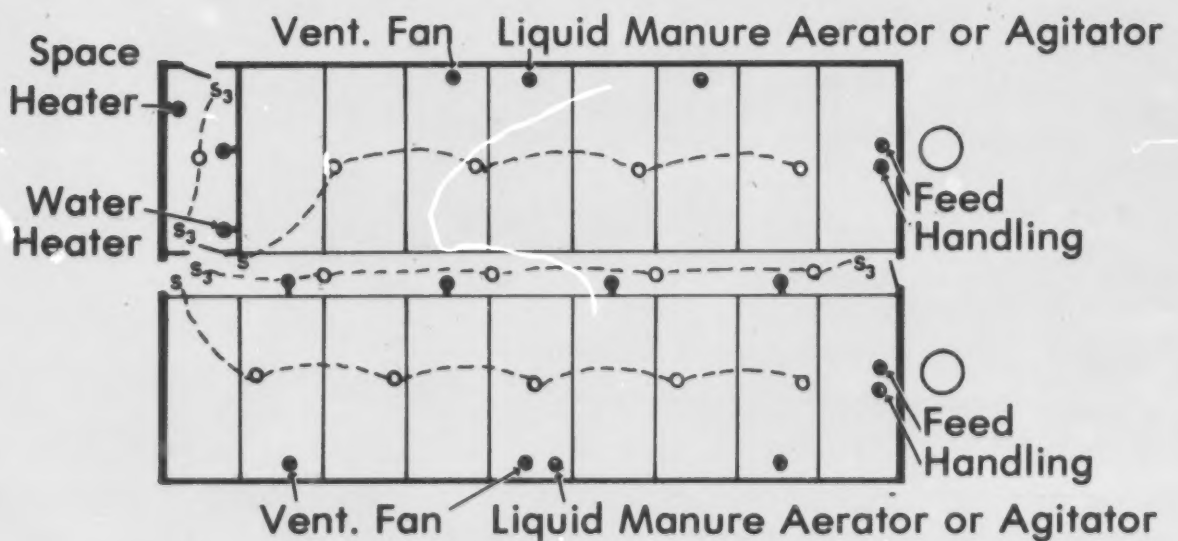
Lighting For Stanchion Barn, 340
Face-Out Arrangement

Hog Needs

TM-2

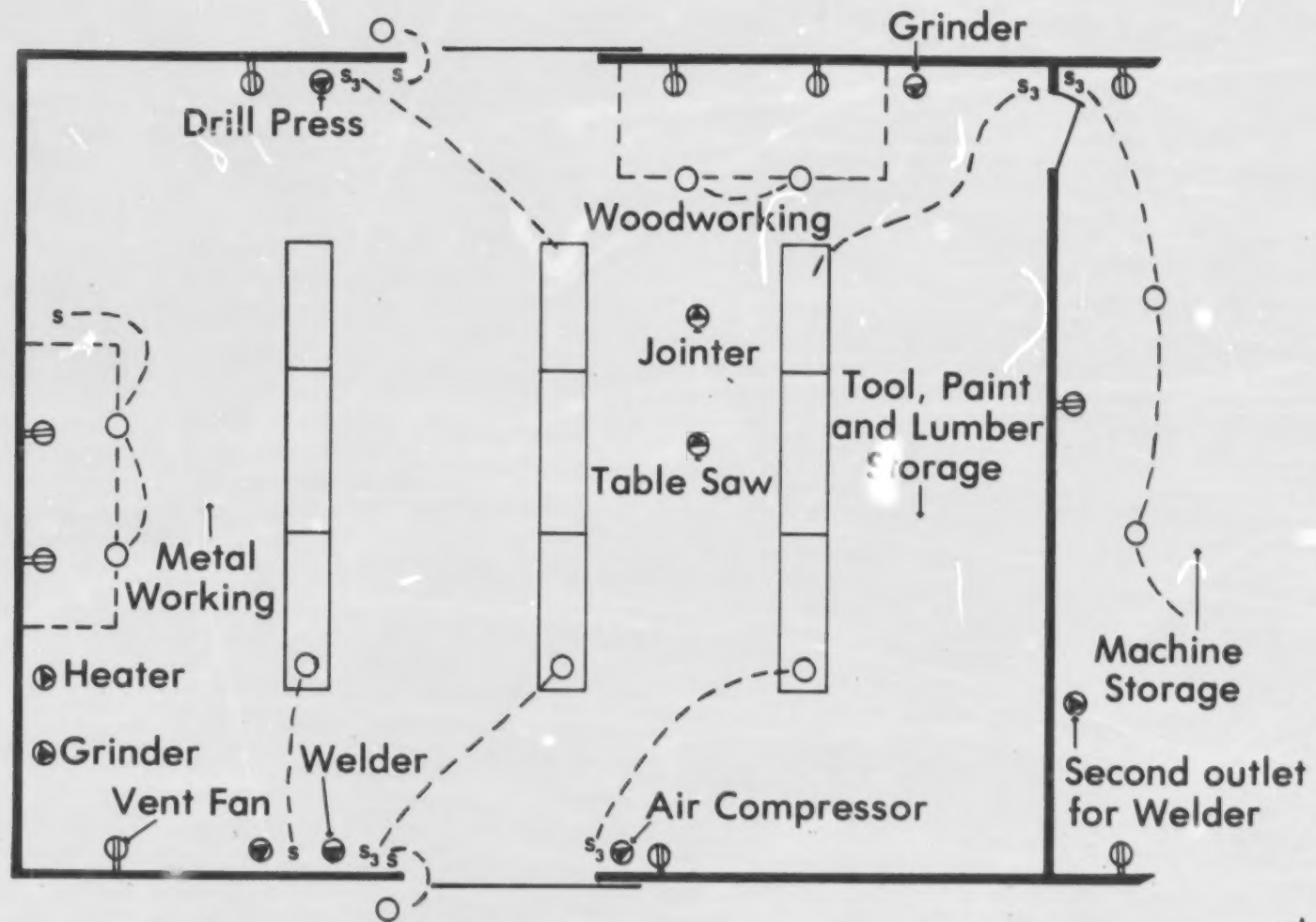


12-Pen Hog Farrowing House



Hog Finishing Building

Farm Shop Needs



Farm Shop and Adjoining Machine Storage

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 7 - How are the wiring needs for a farm building calculated by the builder?

Objective: At the conclusion of the lesson, the student will be able to calculate the electrical power needs of a farm building.

Study Questions:

1. What are some rules of thumb to apply when calculating the circuit needs of a structure?
2. What is the procedure for computing the load in a farm building?
3. What is the procedure for selecting the conductor size?

References:

1. Agricultural Wiring Handbook, Food and Energy Council, Inc., 909 University Avenue, Columbia, MO 65211.
2. Computing Electrical Service Needs for Your Home, Extension Bulletin, Number 1760, UMC.
3. Practical Farm Wiring Demonstrations, by Curtis Weston. Edition I or II.

Handouts:

1. HO #1: Farm Shop
2. HO #2: Dairy Barn
3. HO #3: Wire Tables
4. HO #4: Computing Electrical Service Needs For Your Home

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 7 - How are the wiring needs for a farm building calculated by the builder?

TEACHING PROCEDURE

- A. Review
- B. Motivation - How many feet of wire go into the wiring of a building? How many circuits are needed in each building? One? Two? More? Show a wiring plan to the class or look at the school shop wiring plans.
- C. Assignment - Count the number of circuits and the total amperage load in a building on your own farm. See if there is room for expansion.
- D. Supervised Study - Practical Farm Wiring Demonstrations; Section 1: Exercise E
- E. Discussion

1. When planning the number of circuits to be included in a building, several rules need to be considered to help prevent under planning the circuits in a structure.

What are some rules of thumb to apply when calculating the circuit needs of a structure?

- 1) Lighting or convenience outlet for each 150 square feet of floor
 - 2) Minimum 3 watts of lighting per square foot
 - 3) Convenience outlet for each 6 feet of linear wall space in each direction or every 12 feet
 - 4) 20-amp branch circuit for each 500 square feet, or
 - 5) 15-amp branch circuit for each 375 square feet
 - 6) Small appliance branch circuit of 20-amp, 3-wire 115-230 volts for office with refrigerator
 - 7) Water heater circuit 30-amp, 230 volts, 2-wire
 - 8) Fans use 20-amp at 115 volts
 - 9) Water pump circuit 20-amp, 115/230 volts, 2-wire
 - 10) Workshop bench circuit 20-amp, 115/230 volts, 3-wire
 - 11) Use conduit whenever possible to prevent moisture and physical damage
 - 12) For motors 1-hp = 1000 watts at 100% efficiency, use 1000 watts for calculations or 8-amps.
2. To determine the completed load in a farm building other than a residence, follow this procedure. Two examples are provided as well as the Extension Bulletin on load calculation.

What is the procedure for computing the load in a farm building?

- 1) The full-load current of the largest motor x 1.25. Where two or more motors are of equal size, apply this 125% factor to one. See 1978 National Electrical Code (NEC), Sections 430-22, 430-24, and Table 430-148. In the case of re-rate motors use nameplate full-load amp.
- 2) The full-load currents of all other large or permanently connected items of equipment. (Usually this will include equipment of 1500W or 1/2-hp or more).
- 3) The convenience outlets, at 1 1/2-amp per outlet at 115V. This will take account of plug-in appliances such as portable fans, heaters, drills, clippers, etc. See NEC, Section 220-2.
- 4) The lighting load at 1 1/2-amp per outlet at 115V unless the character of the lighting installation is such that some other factor would apply (such as a poultry laying house where 40 or 50W per outlet might be installed or a building with higher intensity lighting averaging 200 or more W per outlet). See NEC, Section 220-2.
- 5) For a 120/240V service, add all amp at 230V. To this sum add one-half the total of all amp at 115V. This will give the total connected or computed load in amp on the 3-wire service or feeder. Apply demand factors of NEC, Section 220-40, except in areas where local regulations do not recognize such demand factors.
- 6) For a 120V service, add all amp at 115V as determined above in Steps 1, 2, 3 and 4.
- 7) Refer to HO #3 for conductor sizes for 3-wire, 120/240V services.
- 8) Refer to Tables 10 or 11 for conductor sizes for 2-wire 120V services.
- 9) Section 220-40 of NEC is used to determine size of feeder if two or more circuits are involved.
- 10) Example one is a farm shop and can be used in two ways. Use HO #1:
 - a) As an example with all figures provided
 - b) As a learning exercise with figures withheld
 - c) Tables are also provided with the example. HO #3.
- 11) Example two is a dairy barn. Use HO #2.
- 12) Take into account that not all equipment will be running at the same time so subtractions can be made.
- 13) To calculate the load for an individual farm building follow this step by step calculation developed in Wiring Simplified:

- a) Amperage at 240 volts of all load that will operate at the same time _____ amps
 - b) If a) includes the largest motor in the building, add 25% of the amperage of the motor _____ amps
 - c) If a) does not include the largest motor, show here 125% of the amperage of the motor _____ amps
 - d) Total of a) + b) + c) _____ amps
 - e) Amperage at 240 volts of all other connected loads in the building. (Total amps - a) = _____ amps
 - f) Total of d) + e) _____ amps
- 14) Now to determine the minimum service for the building, use one of the following steps:
- a) If d) + e) is 30 or less, and not over 2 circuits, use a 30-amp switch and a number 8 wire. If more than 3 circuits, use a 60-amp switch and a number 6-wire.
 - b) If d) + e) is over 30 but under 60, use 60-amp switch and a number 6-wire.
 - c) If d) is less than 60 and if d) + e) is over 60, start with (d + e). Add together 100% of the first 60-amp plus 50% of the next 60-amp plus 25% of the remainder. For example, if (d + e) = 140, add 60 + 30 + 5 for a total of 95-amps. Use a 100-amp switch and wire with ampacity of 95-amps or over.
 - d) If d) is over 60-amps start with 100% of d). Add 50% of the first 60-amps of e), plus 25% of the remainder of e).
- 15) Check the wire size tables for proper size and type. Be sure to allow for future expansion. Number 10 wire is acceptable for up to 50 ft., and a number 8 for longer spans. Allow for seasonal length changes in the wire, copper wire 100 ft. or longer will shorten several inches in the winter.

3. As was demonstrated in the examples in study question two, the entrance cable is easily determined by finding the size in convenient tables. Use of the tables are important and need practice.

What is the procedure for selecting the conductor size?

- 1) Look up amps on left margin Table 16 for copper, Table 17 for aluminum. Use HO #3.
- 2) Select type of wire.
- 3) Read value from table.

- 4) Example:
 - a) Aluminum service cable
 - b) 200-amp load
 - c) Use Table 17 column 3 (HO #3)
 - d) Number 250 CM Type RH cable
- 5) Neutral usually can be two sizes smaller than ungrounded conductors.

F. Summary

The idea behind checking the load in the planning stages is to be sure sufficient power is available to run essential machinery and allow for future expansion.

G. Evaluation

Answers to Exam

1.
 - a. Amperage 92.4
 - b. 67-amps
 - c. Wire size number 2

348

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 7 - How are the wiring needs for a farm building calculated by the builder?

EXAM

1. Find the following:

- a. Amperage for building
- b. Demand after applying NEC, Section 220-40.
- c. Wire size of aluminum service entrance cable Type RH

Problem

Farm Building, 230 volt system
10 lights at 1 1/2-amps, 115 volts
Heaters 3kw
Hay elevator 1-hp
Hay conveyor 3/4-hp
Welder 35-amps
Water heater 2kw

Remember to apply NEC, Section 220-40.

FARM SHOP

10 lighting outlets		
6 convenience outlets		
16 outlets at 1½-amp - 24-amp,	amp	V
115V.....	= 12	230
Heater, 3 kw.....	= 13	230
Lathe, 1 hp; 8-amp x 1.25.....	= 10	230
Saw, ¾ hp.....	= 6.9	230
Air compressor, ½ hp.....	= 4.9	230
Welder.....	= <u>35</u>	230
	81.8 or 82-amp, 230 V	

If the welder (35-amp), heater (13-amp) and half of the lighting (6 amp) were in use, we would have a total of 54-amp without diversity. Applying NEC, Section 220-40 we have:

First 60-amp at 100 percent demand factor.....	= 60-amp
Remaining 22-amp at 50 percent demand factor... ..	= 11-amp
	Demand = 71-amp at 230 V

Since the loads expected to operate without diversity total less than 60-amp, the minimum of 60-amp should be computed at 100 demand factor.

From HO-3, Tables 16 and 17 this will require No. 4 Type RH copper or No. 2 Type RH aluminum conductors in the service entrance. The neutral conductor could be No. 6 copper or No. 4 aluminum unless local regulations require the same size as ungrounded conductors.

350

DAIRY BARN

30 lighting outlets			
10 convenience outlets			
40 outlets at 1½ amp = 60 amp,		amp	V
115V.....	=	30	230
2-1/6 hp ventilating fans at 4.4-amp, 115V.....	=	2.2	230
1 silo unloader, 5 hp; 28 amp x 1.25.....	=	35	230
1 feed conveyor, 5 hp.....	=	28	230
Barn cleaner, 5 hp.....	=	28	230
Hay elevator, 1 hp.....	=	8	230
Hay conveyor, 3/4 hp.....	=	6.9	230
Milker, 1½ hp.....	=	10	230
Milk pump, ½ hp.....	=	4.9	230
Tank truck outlet, 1 hp.....	=	8	230
Milk cooler, 3 hp.....	=	17	230
Milk house heater, 2 kw.....	=	9	230
Water heater, 3 kw.....	=	13	230
Water pump, ½ hp.....	=	4.9	230
		204.9 or 205-amp	230V

Section 220-21 of the NEC provides that, in adding branch circuit loads to determine the feeder load, the smaller of two dissimilar loads may be omitted where it is unlikely both loads will be served simultaneously. It is unlikely the milk house heater (9-amp) and ventilating fan (2.2-amp) will be running in the summertime when hay dryers are in use, so we can subtract these loads ($9 + 2.2 = 11.2$) from the total.

$$\begin{array}{r}
 \text{Total load } 205.0\text{-amp} \\
 - 11.2\text{-amp} \\
 \hline
 193.8 \text{ or } 194\text{-amp at } 230 \text{ V}
 \end{array}$$

Prior to the 1965 NEC, this barn would have required a 200-amp service which would not have provided spare capacity for future loads. A barn with all this equipment should have a 200-amp service anyway to provide for future load additions, but the application of Section 220-40 will show how much spare capacity is available.

First, decide what loads are likely to be drawn at the same time - that is, without diversity. During haying season, hay elevator and conveyor will probably not be running while the barn cleaner is being operated; so we can leave them out of consideration. Barn cleaner and milker will hardly run at the same time. The milk cooler will probably start before milking is finished. After the milker is shut off and milk house chores are being done, the water heater could come on, and the milk cooler would be running. If this were in the evening, some lights might be on. Thus we can say loads operating without diversity are:

Silo unloader.....	=	amp	35
Feed conveyor.....	=	28	
Milk cooler.....	=	17	
Water heater.....	=	13	
Lights.....	=	5	
Loads operating without diversity.....	=	98	

HO-2 (cont.)

We have already determined the net total load in the building is 194-amp. Subtracting, we have $194 - 98 = 96$ -amp of remaining load. Sixty amp of this can be figured at 50 percent demand factor, leaving 36-amp at 25 percent demand factor, thus:

	amp	V
Loads expected to operate without diversity....	= 98	230
Next 60-amp at 50 percent.....	= 30	230
Remaining 36-amp at 25 percent.....	= <u>9</u>	<u>230</u>
Total computed demand load.....	= 137	230

With a computed demand load of 137-amp, the service entrance conductors must be rated at least at 150-amp. This would provide spare capacity of 13-amp for added loads operating without diversity or $13 \div 0.25 = 52$ -amp of other loads operating with diversity. If a 200-amp service were installed, spare capacity would be $200 - 137$ or 63-amp. This would be equivalent to 2 more 5 hp silo unloaders operating without diversity ($2 \times 28 = 56$ amp) plus a 5 hp bunk feeder ($28 \times 0.25 = 7$ -amp). If all the spare capacity were used for loads operating with diversity, the spare capacity of 63-amp could serve $63 \div 0.25$ or 246 amp of added load.

352

16.

Minimum Allowable Size of Conductor

Copper up to 400 Amperes, 230-240 Volts, Single Phase, Based on 2% Voltage Drop

Load in Amps	In Cable, Conduit, Earth		Overhead in Air*	Length of Run in Feet	
	Types R, T, TW	Types RH, RHW, THW	Bare & Covered Conductors	Compare size shown below with size shown to left of double line. Use the larger size.	
5	12	12	10	50	60
7	12	12	10	75	100
10	12	12	10	125	150
15	12	12	10	175	200
20	12	12	10	225	250
25	10	10	10	275	300
30	10	10	10	350	400
35	8	8	10	450	500
40	8	8	10	550	600
45	6	8	10	650	700
50	6	6	10	750	800
60	4	6	8	800	850
70	4	4	8	850	900
80	2	4	6	900	950
90	2	3	6	950	1000
100	1	3	6	1000	1050
115	0	2	4	1050	1100
130	00	1	4	1100	1150
150	000	0	2	1150	1200
175	4/0	00	2	1200	1250
200	250	000	1	1250	1300
225	300	4/0	0	1300	1350
250	350	250	00	1350	1400
275	400	300	00	1400	1450
300	500	350	000	1450	1500
325	600	400	4/0	1500	1550
350	600	500	4/0	1550	1600
375	700	500	250	1600	1650
400	750	600	250	1650	1700

17.

Minimum Allowable Size of Conductor

Aluminum up to 400 Amperes, 230-240 Volts, Single Phase, Based on 2% Voltage Drop

Load in Amps	In Cable Conduit, Earth		Overhead in Air*	Length of Run in Feet	
	Types R, T, TW	Types RH, RHW, THW	Bare & Covered Conductors Single Triplex	Compare size shown below with size shown to left of double line. Use the larger size.	
5	12	12	10	50	60
7	12	12	10	75	100
10	12	12	10	125	150
15	12	12	10	175	200
20	10	10	10	225	250
25	10	10	10	275	300
30	8	8	10	350	400
35	6	8	10	450	500
40	6	8	10	550	600
45	4	6	10	650	700
50	4	6	8	750	800
60	2	4	6	800	850
70	2	2(a)	6	850	900
80	1	2(a)	6	900	950
90	0	2(a)	4	950	1000
100	0	1(a)	4	1000	1050
115	00	0(a)	2	1050	1100
130	000	00(a)	2	1100	1150
150	4/0	000(a)	1	1150	1200
175	300	4/0(a)	0	1200	1250
200	350	250	00	1250	1300
225	400	300	000	1300	1350
250	500	350	000	1350	1400
275	600	500	4/0	1400	1450
300	700	500	250	1450	1500
325	800	600	300	1500	1550
350	900	700	300	1550	1600
375	1M	700	350	1600	1650
400		900	350	1650	1700

Computing Electrical Service Needs for Your Home

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The capacity of electrical service has a great deal to do with occupant satisfaction in a home. An oversized service increases costs, but an undersized service may limit the use of electrical equipment.

Select a panel with an adequate number of fuse or circuit-breaker branch circuit spaces to allow connection of presently planned circuits plus at least six spaces for future use.

Panels with either circuit breakers or fuses are equally acceptable. Statements in this guide are generalizations from the National Electrical Code (NEC). For additional information, you may want to consult an electrician or refer to the current issue of the National Electrical Code. Keep in mind that recommendations in this guide are minimum requirements.

Minimum Size

A 100-ampere, three-wire service is required when (a) there are six or more two-wire branch circuits or (b) the initial computed load is 10 kilowatts or more.

- A 100-ampere, three-wire service is required when (a) there are six or more two-wire branch circuits or (b) the initial computed load is 10 kilowatts or more.
- A 60-ampere service may be installed for smaller loads but is seldom recommended.

Information Needed to Compute Service Capacity

The National Electrical Code (Article 220) gives requirements for calculating loads in residences for one family. The general requirements are:

1. Compute the minimum general load for lighting by multiplying the total floor space in square feet of all floors by three watts. The first section on the calculation form in this guide gives a method to determine the number of circuits needed. These circuits supply receptacle outlets and ceiling outlets except receptacles and outlets in those rooms mentioned in Number 2, below.

2. The kitchen needs at least two 20-ampere circuits. For computation, you may enter these at 1,500 watts each. These circuits may extend into a pantry, breakfast room, dining room, family room, or all of these rooms.

3. The laundry needs one 20-ampere circuit. For computation, you may also enter this circuit at 1,500 watts.

4. Individual circuits are required for the following:

- range (usually about 8,000 watts)
- water heater (usually about 4,500 watts)
- clothes dryer (minimum of 5,000 watts)
- electric heat*
- air conditioning*
- additional circuits (as required for such items as a food freezer, shop, and pump)

*Provide service capacity for the larger of heat or air conditioning. If you use a heat pump, assume that the compressor and the furnace heaters will operate simultaneously.

NOTES

1. *The service:* The conductors and equipment for delivering energy from the electricity supply system to the wiring system of the premises served. (NEC Article 100 definitions)
2. *Service conductors* shall not be smaller than No. 8 copper or No. 6 aluminum. (NEC 230-5 and 230-23 and exception)
3. *Service entrance conductors* to be sized per NEC Tables 310-16 through 310-19 and notes to tables 310-16 through 310-19 note no. 3.
4. *Service entrance* shall be rated 100 amperes (minimum) for loads computed at 10 Kilowatts or more. [NEC 230-41 (a), (b), (1), (2)]
5. *Service disconnecting means* shall have a rating of not less than 100 amperes. [NEC 230-79 (c)]
6. NEC Article 220-30 and Chapter 9 (tables and examples B) list other optional methods for calculating services.

Residential Service Calculations*

HO-4 cont.

General Lighting Circuits

A. _____ ft. x _____ ft. x (3 minimum) = _____ watts
 (length) (width) (watts/sq. ft.)
 _____ ÷ 115 volts = _____
 (total watts) (amperes)
 _____ ÷ 15 amperes per circuit = _____
 (amperes) (no. of circuits)

Small Appliance Circuits (minimum of two 20-ampere circuits required)

B. _____ circuits x 1500 watts = _____ watts

Laundry Circuits (minimum of one 20-ampere circuit required)

C. _____ circuits x 1500 watts = _____ watts

Diversity Calculations

D. add watts of lines A, B, and C = _____ watts

E. first 3000 watts of line D at 100% = 3,000 watts

F. line D minus E = _____ watts

G. 35% of line F (line F x .35) = _____ watts

H. add lines E and G net computed load _____ total watts

Special Circuits

I. _____ electric ranges = _____ watts total watts

J. _____ clothes dryers = _____ watts total watts

K. _____ electric space heating or air conditioning at 100% = _____ watts total watts

L. _____ water heaters at 100% = _____ watts total watts

M. _____ = _____ watts total watts

N. _____ = _____ watts total watts

O. _____ = _____ watts total watts

P. _____ = _____ watts total watts

Total Computed Service Load total of lines H through P _____ total watts

Total Computed Service Load _____ ÷ 230 volts = _____ amperes

recommended service cabinet _____ amperes

recommended service entrance conductors—type and size _____

type of service (115 V -- 115/230) _____

recommended number of circuits (from the first section) _____

*This method of calculation is based on National Electrical Code Article 220. See it for more information.

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 8 - How are the sizes of the feeder wires determined for the farm building?

Objective: At the conclusion of the lesson, the student will be able to select feeder wires based on amperage load and wire run.

Study Questions:

1. What are feeder wires?
2. How does demand load affect the feeder size?
3. How does length and voltage drop affect feeder size?

References:

1. Agricultural Wiring Handbook, Food and Energy Council, Inc., 909 University Avenue, Columbia, MO 65211.
2. Practical Farm Wiring Demonstrations, by Curtis Weston.

Handouts:

1. HO #1: Feeders
2. HO #2: Tables
3. HO #3: Example 1, 1a, 2
4. HO #4: Example 3, 3a
5. HO #5: Computing Farm Loads NEC
6. HO #6: Feeder Load NEC

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 8 - How are the sizes of the feeder wires determined for the farm building?

TEACHING PROCEDURE

- A. Review calculating demand load.
- B. Motivation - What are feeder wires? How large is too large? Can a feeder be too small? What can happen if the wire is too big? too small?
- C. Assignment - Locate the feeder wires at your home. Are there more than two wires going into the house? What services are connected to the other buildings?
- D. Supervised Study - Practical Farm Wiring Demonstrations; Section 1: Exercises A and G
- E. Discussion
 1. The wire connecting the pole to the building is called the feeder wire. Is there more than one type? How are they different? Use HO #1.

What are feeder wires?

- 1) Two types used in farm wiring
 - a) Feeders connecting service entrance conductors of a building to metering point
 - b) Feeders connecting branch-circuit panel in a building to service equipment in another part of building
 - 2) Type a) can be overhead or underground
 - 3) Type a) also called service drops
 - 4) Second type feeders
 - a) Feeder from service equipment in dairy barn to branch-circuit panel in attached milk house
 - b) Feeder from service equipment in a residence to a branch-circuit panel on second floor
 - 5) Data needed to select conductor sizes
 - a) Demand load
 - b) Length of feeder and allowable voltage drop
 - c) Type of conductor
 - d) Type of insulation
2. Earlier in this unit we calculated the demand load for a farm structure. This is where the application of the skill is important.

How does demand load affect the feeder size?

- 1) For a feeder supplying the service entrance to a building, load is same as is used to determine size of service entrance conductors.
 - 2) For a feeder supplying two or more buildings with similar functions, calculate using NEC Sections 220-40 and 220-41. Refer to HO #5.
 - 3) Demand load is expressed in amps at the voltage of the feeder.
 - 4) To select the minimum conductor size refer to the left of double line on HO #2, Tables 10 to 21.
 - 5) For the size of the neutral in a 3-wire feeder, determine maximum possible unbalanced load between conductors. Omit all 240V loads not connected to the neutral. Refer to HO #6.
3. Other major factors in the determination of the feeder size is the length and voltage drop of the line. What causes voltage drop? Is longer better?

How does length and voltage drop affect feeder size?

- 1) Satisfactory operation of equipment can be assured if voltage drop from meter to outlet is less than 5%.
 - a) Three percent feeders and services
 - b) Two percent branch circuits
 - c) If equipment is sensitive keep drop overall at 1-2%.
- 2) Work through the examples provided to develop skill with the tables.

F. Summary

Before selecting the wire size for the feeders you need to know the load, length of feeders, voltage drop, type of conductor, and type of insulation.

G. Evaluation

Answers to Exam

1. Size 2
2. Size 000
3. Size 350
4. Size 300

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 8 - How are the sizes of the feeder wires determined for the farm building?

EXAM

Directions: Find the wire size needed for the following situations using H0 #2, Tables 16 and 17.

1. Copper wire - 50-amps, 230 volts, 250 feet, Type RH
2. Copper wire - 200-amps, 230 volts, 150 feet, Type RH
3. Aluminum wire - 70-amps, 230 volts, 600 feet, Type R
4. Aluminum wire - 250-amps, 230 volts, 150 feet, Type RH

FEEDERS

215-1. Scope. This article covers the installation requirements and minimum size and ampacity of conductors for feeders supplying branch-circuit loads as computed in accordance with Article 220. The requirements of Section 215-8 shall apply to feeders and other applications where identification is equally necessary.

215-2. Minimum Rating and Size. Feeder conductors shall have an ampacity not lower than required to supply the load as computed in Parts B, C, and D of Article 220. The minimum sizes shall be as specified in (a) and (b) below under the conditions stipulated. Feeder conductors for a one-family dwelling or a mobile home need not be larger than service-entrance conductors. Note 3 of Table 310-16 shall be permitted to be used for conductor size.

(a) For Specified Circuits. The feeder conductors shall not be smaller than No. 10 where the load supplied consists of the following number and types of circuits: (1) Two or more 2-wire branch circuits supplied by a 2-wire feeder; (2) More than two 2-wire branch circuits supplied by a 3-wire feeder; (3) Two or more 3-wire branch circuits supplied by a 3-wire feeder.

(b) Ampacity Relative to Service-Entrance Conductors. The feeder conductor ampacity shall not be lower than that of the service-entrance conductors where the feeder conductors carry the total load supplied by service-entrance conductors No. 6 or smaller.

(c) Overloaded Feeders. Where at any time feeder conductors are or will be overloaded the feeder conductors shall be increased in ampacity to accommodate the actual load served.

See Examples 1 through 8 in Chapter 9. NEC

Conductors for feeders as defined in Article 100, sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads and where the maximum total voltage drop on both feeders and branch circuits to the farthest outlet does not exceed 5 percent, will provide reasonable efficiency of operation.

See Section 210-19(a) for voltage drop for branch circuits.

215-3. Overcurrent Protection. Feeders shall be protected against overcurrent in accordance with the provisions of Part A of Article 240.

215-4. Feeders with Common Neutral.

(a) Feeders with Common Neutral. Feeders containing a common neutral shall be permitted to supply two or three sets of 3-wire feeders, or two sets of 4-wire or 5-wire feeders.

(b) In Metal Raceway or Enclosure. Where installed in a metal raceway or other metal enclosure, all conductors of all feeders using a common neutral shall be enclosed within the same raceway or other enclosure as required in Section 300-20.

215-5. Diagrams of Feeders. If required by the authority having jurisdiction, a diagram showing feeder details shall be provided prior to the installation of the feeders. Such a diagram shall show the area in square feet of the building or other structure supplied by each feeder, the total connected load before applying demand factors and the size and type of conductors to be used.

215-6. Feeder Conductor Grounding Means. Where a feeder supplies branch circuits in which grounding conductors are required, the feeder shall include or provide a grounding means to which the grounding conductors of the branch circuits shall be connected.

215-7. Ungrounded Conductors Tapped from Grounded Systems. Two-wire DC circuits and AC circuits of two or more ungrounded conductors may be tapped from the ungrounded conductors of circuits having a grounded neutral conductor. Switching devices in each tapped circuit shall have a pole in each ungrounded conductor.

215-8. Means of Identifying Conductor with the Higher Voltage to Ground. On a 4-wire, delta-connected secondary where the midpoint of one phase is grounded to supply lighting and similar loads, the phase conductor having the higher voltage to ground shall be identified by an outer finish that is orange in color or by tagging or other effective means. Such identification shall be placed at any point where a connection is made if the neutral conductor is also present.

215-9. Ground-Fault Personnel Protection. Feeders supplying 15- and 20-ampere receptacle branch circuits shall be permitted to be protected by a ground-fault circuit-interrupter approved for the purpose in lieu of the provisions for such interrupters as specified in Section 210-8.

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TABLES

Copper up to 200 Amperes, 115-120 Volts, Single Phase, Based on 2% Voltage Drop

Minimum Allowable Size of Conductor				Length of Run in Feet																							
Load in Amps	In Cable, Conduit, Earth		Overhead in Air*	Compare size shown below with size shown to left of double line. Use the larger size.																							
	Types R, T, TW	Types RM, RHW, THW	Bare & Covered Conductors	30	40	50	60	75	100	125	150	175	200	225	250	275	300	350	400	450	500	550	600	650	700		
5	12	12	10	12	12	12	12	12	10	10	10	10	10	8	8	8	8	6	6	6	6	4	4	4	4		
7	12	12	10	12	12	12	12	10	10	8	8	8	8	6	6	6	6	4	4	4	4	3	3	2	2		
10	12	12	10	12	12	10	10	8	8	6	6	6	6	4	4	4	4	3	3	3	2	2	2	2	2		
15	12	12	10	12	10	10	8	6	6	6	6	4	4	4	4	4	3	2	2	2	1	1	1	0	0		
20	12	12	10	12	10	8	6	6	4	4	4	4	3	3	2	2	2	1	1	1	0	0	0	0	0		
25	10	10	10	10	8	6	6	4	4	4	3	3	2	2	2	1	1	0	0	0	0	0	0	0	0		
30	10	10	10	10	8	6	4	4	4	3	2	2	1	1	1	0	0	0	0	0	0	0	0	0	0		
35	8	8	10	10	8	6	4	4	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0		
40	8	8	10	10	8	6	4	4	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0		
45	6	8	10	10	8	6	4	4	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0		
50	6	6	10	10	8	6	4	4	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0		
60	4	6	8	8	6	4	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
70	4	4	8	8	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
80	2	4	6	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
90	2	3	6	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
100	1	3	6	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
115	0	2	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
120	0	1	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
130	0	0	2	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
140	0	0	2	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
150	0	0	2	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
175	0	0	2	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
200	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

Aluminum up to 200 Amperes, 115-120 Volts, Single Phase, Based on 2% Voltage Drop

Minimum Allowable Size of Conductor				Length of Run in Feet																							
Load in Amps	In Cable, Conduit, Earth		Overhead in Air*	Compare size shown below with size shown to left of double line. Use the larger size.																							
	Types R, T, TW	Types RM, RHW, THW	Bare & Covered Conductors	30	40	50	60	75	100	125	150	175	200	225	250	275	300	350	400	450	500	550	600	650	700		
5	12	12	10	12	12	12	12	10	10	8	8	8	8	6	6	6	6	4	4	4	4	3	3	3	3		
7	12	12	10	12	12	12	10	10	8	6	6	6	6	4	4	4	4	3	3	3	2	2	2	2	1		
10	12	12	10	12	10	10	8	8	6	6	6	6	4	4	4	4	3	3	3	2	2	1	1	0	0		
15	12	12	10	12	10	8	6	6	4	4	4	3	3	2	2	2	2	1	1	1	0	0	0	0	0		
20	10	10	10	10	8	6	6	4	4	3	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0		
25	10	10	10	10	8	6	4	4	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0		
30	8	8	10	10	8	6	4	3	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
35	8	8	10	10	8	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
40	8	8	10	10	8	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
45	4	6	10	10	8	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
50	4	6	8	8	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
60	2	4	6	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
70	2	2	6	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
80	1	2	6	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
90	0	2	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
100	0	1	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
115	0	0	2	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
120	0	0	2	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
130	0	0	2	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
140	0	0	2	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
150	0	0	2	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
175	0	0	2	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
200	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

Copper up to 200 Amperes, 115-120 Volts, Single Phase, Based on 3% Voltage Drop

12.

Minimum Allowable Size of Conductor

Copper up to 200 Amperes, 115-120 Volts, Single Phase, Based on 3% Voltage Drop

Load in Amps	In Cable, Conduit, Earth		Overhead in Air*	Length of Run in Feet																							
	Types R, T, TW	Types RM, RHW, THW	Bare & Covered Conductors	Compare size shown below with size shown to left of double line. Use the larger size.																							
				30	40	50	60	75	100	125	150	175	200	225	250	275	300	350	400	450	500	550	600	650	700		
5	12	12	10	12	12	12	12	12	12	12	12	12	10	10	10	10	8	8	8	8	8	8	6	6	6	6	
7	12	12	10	12	12	12	12	12	12	12	10	10	10	8	8	8	8	8	6	6	6	6	6	6	4	4	3
10	12	12	10	12	12	12	12	12	10	10	8	8	8	8	6	6	6	6	6	4	4	4	4	4	4	3	2
15	12	12	10	12	12	12	10	10	8	8	8	8	6	6	6	6	4	4	4	4	3	3	3	2	2	2	1
20	12	12	10	12	12	10	10	8	8	6	6	6	6	4	4	4	4	3	3	2	2	2	1	1	0	0	0
25	10	10	10	10	10	8	8	6	6	6	4	4	4	3	3	2	2	2	1	1	1	0	0	0	0	0	0
30	10	10	10	10	10	8	8	6	6	4	4	4	3	3	2	2	2	1	1	0	0	0	0	0	0	0	0
35	8	8	10	10	10	8	8	6	6	4	4	3	3	2	2	2	1	1	0	0	0	0	0	0	0	0	0
40	8	8	10	10	10	8	8	6	6	4	4	3	2	2	2	2	1	0	0	0	0	0	0	0	0	0	0
45	6	8	10	10	10	8	8	6	4	4	4	3	2	2	1	1	1	0	0	0	0	0	0	0	0	0	0
50	6	6	10	10	10	8	8	6	4	4	3	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
55	4	6	8	8	8	6	6	4	4	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
60	4	4	8	8	8	6	6	4	3	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65	2	4	6	6	6	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	2	3	6	6	6	4	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75	1	3	6	6	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80																											
85																											
90																											
95																											
100																											
115	0	2	4	6	4	4	4	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120	00	1	4	6	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130	000	0	2	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140	0	0	2	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
150	0	0	2	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
160	0	0	2	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
175	0	0	2	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200	0	0	1	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Minimum Allowable Size of Conductor

Aluminum up to 200 Amperes, 115-120 Volts, Single Phase, Based on 3% Voltage Drop

13.

13.

Load in Amps	In Cable		Overhead in Air ^a		Length of Run in Feet																											
	Conduit, Earth		Bare & Covered Conductors		Compare size shown below with size shown to left of double line. Use the larger size.																											
	Types R, T, TW	Types RM, RHW, THW	Single	Triplex	30	40	50	60	75	100	125	150	175	200	225	250	275	300	350	400	450	500	550	600	650	700						
5	12	12	10		12	12	12	12	12	12	10	10	10	8	8	8	8	6	6	6	6	6	6	4	4	4	4					
7	12	12	10		12	12	12	12	10	10	10	10	8	8	8	8	6	6	6	6	4	4	4	4	3	3	3					
10	12	12	10		12	12	12	10	10	10	8	8	8	8	6	6	6	6	4	4	3	3	3	2	2	2	1					
15	12	12	10		12	12	10	8	8	8	8	6	6	6	4	4	4	3	3	2	2	1	1	0	0	0	0					
20	10	10	10		12	10	8	8	6	6	6	4	4	4	3	3	2	2	1	1	0	0	0	0	0	0	0					
25	10	10	10		10	10	8	8	6	6	4	4	3	3	2	2	2	1	0	0	0	0	0	0	0	0	0					
30	8	8	10		10	8	8	6	6	4	4	3	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0					
35	6	8	10		10	8	6	6	6	4	3	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0					
40	6	8	10		10	8	6	6	6	4	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0					
45	4	6	10		10	8	6	6	6	4	3	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0					
50	4	6	8		8	8	6	6	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
60	2	4	6		6	6	6	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
70	2	2	6		6	6	4	4	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
80	1	2	6		6	6	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
90	0	2	4		4	6	4	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
100	0	1	4		4	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
115	00	0	2		2	4	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
130	000	00	2		2	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
150	4/0	000	1		1	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
175	300	4/0	0		0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
200	350	250	00		00	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					

Minimum Allowable Size of Conductor

Copper up to 200 Amperes, 115-120 Volts, Single Phase, Based on 4% Voltage Drop

14.

14.	In Cable, Conduit, Earth		Overhead in Air*		Length of Run in Feet																										
Load in Amps	Types R, T, TW	Types RM, RHW, THW	Bare & Covered Conductors	Compare size shown below with size shown to left of double line. Use the larger size.																											
				30	40	50	60	75	100	125	150	175	200	225	250	275	300	350	400	450	500	550	600	650	700						
5	12	12	10	12	12	12	12	12	12	12	12	12	12	12	12	10	10	10	10	8	8	8	8	8	8	8					
7	12	12	10	12	12	12	12	12	12	12	12	12	12	12	10	10	10	10	8	8	8	8	6	6	6	6					
10	12	12	10	12	12	12	12	12	12	10	10	10	10	10	8	8	8	8	6	6	6	6	4	4	4	4					
15	12	12	10	12	12	12	10	10	10	8	8	8	8	6	6	6	6	4	4	4	4	4	3	3	3	3					
20	12	12	10	12	12	12	10	10	8	8	8	8	6	6	6	6	4	4	4	4	3	3	2	2	2	2					
25	10	10	10	12	12	12	10	8	8	6	6	6	6	4	4	4	4	4	3	3	2	2	1	1	1	1					
30	10	10	10	12	12	10	10	8	6	6	6	6	4	4	4	4	4	3	2	2	1	1	0	0	0	0					
35	8	8	10	12	12	10	10	8	6	6	6	4	4	4	4	3	3	2	2	1	1	0	0	0	0	0					
40	8	8	10	12	10	10	8	6	6	4	4	4	4	4	3	3	2	2	1	1	0	0	0	0	0	0					
45	6	8	10	12	10	10	8	6	6	4	4	4	4	3	3	2	2	1	1	0	0	0	0	0	0	0					
50	6	6	10	10	10	8	8	6	6	4	4	4	3	3	2	2	1	1	0	0	0	0	0	0	0	0					
60	4	6	8	10	8	8	6	4	4	4	4	3	2	2	1	1	1	0	0	0	0	0	0	0	0	0					
70	4	4	8	10	8	6	6	4	4	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0					
80	2	4	6	10	8	6	6	4	4	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0					
90	2	3	6	10	8	6	6	4	4	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0					
100	1	3	6	10	8	6	4	4	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
115	0	2	4	8	6	6	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
130	00	1	4	8	6	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
150	000	0	2	8	4	4	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
175	4/0	00	2	8	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
200	250	000	1	8	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					

15.

Minimum Allowable Size of Conductor

Aluminum up to 200 Amperes, 115-120 Volts, Single Phase, Based on 4% Voltage Drop

15.	In Cable		Overhead in Air*		Length of Run in Feet																						
	Conduit, Earth		Bare & Covered Conductors		Compare size shown below with size shown to left of double line. Use the larger size.																						
	Types R, T, TW	Types RM, RHW, THW	Single	Triplex	30	40	50	60	75	100	125	150	175	200	225	250	275	300	350	400	450	500	550	600	650	700	
5	12	12	10		12	12	12	12	12	12	12	12	12	10	10	10	10	8	8	8	8	6	6	6	6	6	
7	12	12	10		12	12	12	12	12	12	12	10	10	10	8	8	8	8	6	6	6	6	4	4	4	4	
10	12	12	10		12	12	12	12	10	10	10	8	8	8	8	6	6	6	6	4	4	4	4	3	3	3	
15	12	12	10		12	12	12	10	8	8	8	8	6	6	6	4	4	4	4	3	3	2	2	2	1	1	
20	10	10	10		12	12	10	8	8	6	6	6	6	4	4	4	4	3	3	2	2	1	1	0	0	0	
25	10	10	10		12	10	8	8	6	6	4	4	4	4	3	3	2	2	1	1	0	0	0	0	0	0	
30	8	8	10		12	10	8	8	6	4	4	4	3	3	2	2	2	1	0	0	0	0	0	0	0	0	
35	6	8	10		10	10	8	8	6	4	4	3	3	2	2	1	1	0	0	0	0	0	0	0	0	0	
40	6	8	10		10	8	8	6	4	4	3	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0	
45	4	6	10		10	8	8	6	4	4	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	
50	4	6	8		8	8	6	4	4	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	
60	2	4	6		8	6	6	4	3	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
70	2	2	6		8	6	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
80	1	2	6		8	6	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
90	0	2	4		8	6	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
100	0	1	4		8	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
115	00	0	2		6	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
130	000	00	2		4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
150	4/0	000	1		4	3	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
175	300	4/0	0		4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
200	350	350	00		3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

16. Minimum Allowable Size of Conductor

Copper up to 400 Amperes, 230-240 Volts, Single Phase, Based on 2% Voltage Drop

In Cable, Conduit, Earth			Overhead in Air °	Length of Run in Feet																							
Load in Amperes	Types R, T, TW	Types RH, RHW, THW	Bare & Covered Conductors	Compare size shown below with size shown to left of double line. Use the larger size.																							
				50	60	75	100	125	150	175	200	225	250	275	300	350	400	450	500	550	600	650	700	750	800		
5	12	12	10	12	12	12	12	12	12	12	12	12	12	10	10	10	10	8	8	8	8	8	6	6			
7	12	12	10	10	12	12	12	12	12	12	10	10	10	10	8	8	8	8	6	6	6	6	6	6			
10	12	12	10	10	12	12	12	10	10	10	10	8	8	8	6	6	6	6	6	4	4	4	4	4			
15	12	12	10	10	12	10	10	8	8	8	6	6	6	6	4	4	4	4	4	3	3	3	2	2			
20	12	12	10	10	12	10	8	8	8	6	6	6	6	4	4	4	4	3	3	2	2	2	1	1			
25	10	10	10	10	10	8	6	6	6	6	6	4	4	4	4	3	3	2	2	1	1	1	0	0			
30	10	10	10	10	10	8	6	6	6	4	4	4	4	4	3	2	2	1	1	1	0	0	0	0			
35	8	8	10	10	10	8	6	6	4	4	4	4	3	3	2	2	1	1	0	0	0	0	0	0			
40	8	8	10	10	10	8	6	6	4	4	4	3	3	2	2	1	1	0	0	0	0	0	0	0			
45	6	8	10	10	10	8	6	6	4	4	3	3	2	2	1	1	0	0	0	0	0	0	0	0			
50	6	6	10	10	10	8	6	4	4	4	3	2	2	1	1	0	0	0	0	0	0	0	0	0			
60	4	6	8	8	10	8	6	4	4	3	2	2	1	1	1	0	0	0	0	0	0	0	0	0			
70	4	4	8	8	10	8	6	4	4	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0			
80	2	4	6	6	10	8	6	4	4	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0			
90	2	3	6	6	10	8	6	4	4	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0			
100	1	3	6	6	10	8	6	4	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0			
115	0	2	4	6	10	8	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0			
130	0	1	4	4	10	8	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0			
150	0	0	2	4	10	8	6	4	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
175	4/0	0	2	4	10	8	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0			
200	250	0	1	3	10	8	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0			
225	300	4/0	0	3	10	8	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0			
250	350	250	0	2	10	8	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0			
275	400	300	0	2	10	8	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0			
300	500	350	0	1	10	8	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0			
325	600	400	4/0	1	10	8	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0			
350	600	500	4/0	1	10	8	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0			
375	700	500	250	0	10	8	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0			
400	750	600	250	0	10	8	6	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0			

17.

Minimum Allowable Size of Conductor

Aluminum up to 400 Amperes, 230-240 Volts, Single Phase, Based on 2% Voltage Drop

17.

Load in Amperes	In Cable Conduit, Earth		Overhead in Air*		Length of Run in Feet																							
	Types R, T, TW	Types RHW, THW	Bare & Covered Conductors	Single Triplex	Compare size shown below with size shown to left of double line. Use the larger size.																							
					50	60	75	100	125	150	175	200	225	250	275	300	350	400	450	500	550	600	650	700	750	800		
5	12	12	10		12	12	12	12	12	12	12	10	10	10	10	8	8	8	8	6	6	6	6	6	4	4		
7	12	12	10		12	12	12	12	12	10	10	10	8	8	8	8	6	6	6	6	6	4	4	4	4	4		
10	12	12	10		12	12	12	10	10	8	8	8	8	6	6	6	6	4	4	4	4	3	3	3	2	2		
15	12	12	10		12	12	10	8	8	8	6	6	6	6	4	4	4	4	3	3	2	2	2	1	1	0		
20	10	10	10		10	10	8	8	6	6	6	4	4	4	4	3	3	2	2	1	1	0	0	0	0	0		
25	10	10	10		10	8	8	6	6	4	4	4	4	3	3	2	2	1	1	0	0	0	0	0	0	0		
30	8	8	10		8	8	6	6	4	4	4	3	3	2	2	2	1	1	0	0	0	0	0	0	0	0		
35	6	8	10		8	8	6	6	4	4	3	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0		
40	6	8	10		8	6	6	4	4	3	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0		
45	4	6	10		8	6	6	4	4	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0		
50	4	6	8		6	6	4	4	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0		
60	2	4	6	6	6	6	4	3	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
70	2	2(a)	6	4	6	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
80	1	2(a)	6	4	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
90	0	2(a)	4	2	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
100	0	1(a)	4	2	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
115	0	0(a)	2	1	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
130	0	0(a)	2	0	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
150	4/0	0(a)	1	0	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
175	300	4/0(a)	0	0	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
200	350	250	0	4/0	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
225	400	300	0		3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
250	500	350	0		3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
275	600	500	4/0		3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
300	700	500	250		3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
325	800	600	300		3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
350	900	700	300		3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
375	1M	700	350		3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
400		900	350		3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

18.

Minimum Allowable Size of Conductor

Copper up to 400 Amperes, 230-240 Volts, Single Phase, Based on 3% Voltage Drop

in Cable, Conduit, Earth			Overhead in Air*	Length of Run in Feet																							
Load in Amps	Types R, T, TW	Types RH, RHW, THW	Bare & Covered Conductors	Compare size shown below with size shown to left of double line. Use the larger size.																							
				50	60	75	100	125	150	175	200	225	250	300	350	400	450	500	550	600	650	700	800	900	1000		
5	12	12	10	12	12	12	12	12	12	12	12	12	12	12	12	12	10	10	10	10	10	8	8	8	8		
7	12	12	10	12	12	12	12	12	12	12	12	12	12	12	12	10	10	10	10	8	8	8	8	6	6		
10	12	12	10	12	12	12	12	12	12	12	12	12	10	10	10	10	8	8	8	8	6	6	6	6	4		
15	12	12	10	12	12	12	12	12	12	10	10	10	10	8	8	8	6	6	6	6	4	4	4	4	3		
20	12	12	10	12	12	12	10	10	10	8	8	8	8	8	6	6	4	4	4	4	4	3	3	2	2		
25	10	10	10	10	10	10	8	8	8	8	8	6	6	6	4	4	4	4	3	3	2	2	1	1			
30	10	10	10	10	12	10	8	8	8	8	6	6	6	4	4	4	3	3	2	2	1	1	0				
35	8	8	10	10	12	10	8	8	8	6	6	6	4	4	3	3	2	2	1	1	0	0	0				
40	8	8	10	10	10	8	8	6	6	6	6	4	4	4	3	2	2	1	1	0	0	0	0				
45	6	8	10	10	10	8	6	6	6	6	4	4	4	3	2	2	1	1	0	0	0	0	0				
50	6	6	10	10	10	8	6	6	6	6	4	4	4	3	2	2	1	1	0	0	0	0	0				
60	4	6	8	10	8	8	6	6	4	4	4	3	3	2	2	1	1	0	0	0	0	0	4/0				
70	4	4	8	8	8	8	6	6	4	4	3	3	2	2	1	1	0	0	0	0	0	0	250				
80	2	4	6	8	8	6	6	4	4	3	3	2	2	1	1	0	0	0	0	0	0	4/0	250				
90	2	3	6	8	8	6	4	4	4	3	2	2	1	1	1	0	0	0	0	0	0	4/0	300				
100	1	3	6	8	8	6	4	4	3	2	2	1	1	1	0	0	0	0	0	0	4/0	250	300				
115	0	2	4	6	6	6	4	3	3	2	1	1	0	0	0	0	0	0	4/0	4/0	250	250	350				
130	0	1	4	6	6	6	4	3	2	1	1	0	0	0	0	0	0	0	4/0	250	300	350	400				
150	0	0	2	6	6	4	4	3	2	1	1	0	0	0	0	0	0	0	4/0	250	300	350	400				
175	4/0	0	2	6	4	4	2	2	1	0	0	0	0	0	0	0	0	0	300	350	350	400	500				
200	250	0	1	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	350	400	500	500	600				
225	300	4/0	0	4	4	3	1	0	0	0	0	0	0	4/0	4/0	250	300	350	400	500	500	600	700				
250	350	250	0	4	3	2	1	0	0	0	0	0	0	4/0	250	300	350	400	500	500	600	700	800				
275	400	300	0	4	3	2	1	0	0	0	0	0	0	4/0	250	300	350	400	500	500	600	700	800				
300	500	350	0	3	2	1	0	0	0	0	0	0	0	4/0	250	300	350	400	500	500	600	700	750				
325	600	400	4/0	3	2	1	0	0	0	0	0	4/0	250	250	300	350	400	500	500	600	600	700	800				
350	600	500	4/0	2	2	1	0	0	0	0	0	4/0	250	250	300	350	400	500	500	600	700	750	800				
375	700	500	250	2	1	0	0	0	0	4/0	4/0	250	250	300	300	350	400	500	600	600	700	750	800				
400	750	600	250	2	1	0	0	0	0	4/0	250	250	300	350	400	500	500	600	700	750	800	900	1M				

19.

Minimum Allowable Size of Conductor

Aluminum up to 400 Amperes, 230-240 Volts, Single Phase, Based on 3% Voltage Drop

Load in Amps	In Cable Conduit, Earth		Overhead in Air*		Length of Run in Feet																						
	Types R, T, TW	Types RHW, THW	Bare & Covered Conductors		Compare size shown below with size shown to left of double line. Use the larger size.																						
			Single	Triplex	50	60	75	100	125	150	175	200	225	250	300	350	400	450	500	550	600	650	700	800	900	1000	
5	12	12	10		12	12	12	12	12	12	12	12	12	12	10	10	10	8	8	8	8	8	8	6	6	6	6
7	12	12	10		12	12	12	12	12	12	12	12	10	10	10	10	8	8	8	6	6	6	6	4	4	4	4
10	12	12	10		12	12	12	12	12	10	10	10	8	8	8	6	6	6	6	6	6	6	4	4	4	3	3
15	12	12	10		12	12	12	10	8	8	8	8	6	6	6	4	4	4	4	4	3	3	2	2	2	1	1
20	10	10	10		12	12	10	10	8	8	6	6	6	6	4	4	4	3	3	3	2	2	1	1	0	0	0
25	10	10	10		12	10	10	8	8	6	6	6	4	4	4	3	3	2	2	2	2	1	0	0	0	0	0
30	8	8	10		10	10	8	8	6	6	6	4	4	4	3	3	2	2	1	1	0	0	0	0	0	0	0
35	6	8	10		10	10	8	6	6	6	6	4	4	4	3	3	2	1	1	0	0	0	0	0	0	0	0
40	6	8	10		10	8	8	6	6	4	4	4	3	3	2	1	1	0	0	0	0	0	0	0	0	0	0
45	4	6	10		8	8	8	6	4	4	4	3	3	2	2	1	0	0	0	0	0	0	0	0	0	0	0
50	4	6	8		8	8	6	6	4	4	3	3	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0
60	2	4	6	6	8	6	6	4	4	3	3	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
70	2	2(a)	6	4	6	6	6	4	3	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80	1	2(a)	6	4	6	6	4	4	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	2(a)	4	2	6	6	4	3	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	1(a)	4	2	6	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
115	0	0(a)	2	1	4	4	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130	0	0(a)	2	0	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
150	4/0	0	1	0	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
175	300	4/0(a)	0	0	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200	350	250	0	4/0	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
225	400	300	0		2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250	500	350	0		2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
275	600	500	4/0		2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300	700	500	250		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
325	800	600	300		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
350	900	700	300		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
375	1M	700	350		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400		900	350		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

20. Minimum Allowable Size of Conductor

Copper up to 400 Amperes, 230-240 Volts, Single Phase, Based on 4% Voltage Drop

Load in Amperes	In Cable, Conduit, Earth		Overhead in Air*	Length of Run in Feet																							
	Types R, T, TW	Types RH, RHW, THW	Bare & Covered Conductors	Compare size shown below with size shown to left of double line. Use the larger size.																							
				50	60	75	100	125	150	175	200	225	250	300	350	400	450	500	550	600	650	700	800	900	1000		
5	12	12	10	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	10	10	10	10	10	10		
7	12	12	10	12	12	12	12	12	12	12	12	12	12	12	12	12	12	10	10	10	10	8	8	8	8		
10	12	12	10	12	12	12	12	12	12	12	12	12	12	10	10	10	10	8	8	8	8	6	6	6	6		
15	12	12	10	12	12	12	12	12	12	12	10	10	10	10	8	8	8	6	6	6	6	6	4	4	4		
20	12	12	10	12	12	12	10	10	10	10	10	10	8	8	8	6	6	6	6	4	4	4	4	4	3		
25	10	10	10	12	12	12	10	10	10	8	8	8	6	6	6	6	4	4	4	4	4	4	3	3	2		
30	10	10	10	12	12	10	10	10	8	8	8	6	6	6	6	4	4	4	4	4	3	3	2	2	1		
35	8	8	10	12	12	10	10	8	8	8	6	6	6	4	4	4	4	3	3	3	2	2	2	1	1		
40	8	8	10	12	10	10	8	8	8	6	6	6	6	4	4	4	4	3	3	2	2	2	1	1	0		
45	8	8	10	12	10	10	8	8	6	6	6	6	6	4	4	4	3	3	2	2	2	1	1	0	0		
50	6	6	10	12	10	10	8	8	6	6	6	6	4	4	4	3	3	2	2	1	1	1	0	0	0		
60	4	6	8	10	10	10	8	6	6	6	4	4	4	4	3	2	2	1	1	1	0	0	0	0	0		
70	4	4	8	10	10	8	6	6	4	4	4	4	4	3	2	2	1	1	0	0	0	0	0	0	0		
80	2	4	6	10	8	6	6	4	4	4	4	4	3	2	2	1	1	0	0	0	0	0	0	0	0		
90	2	3	6	10	8	6	6	4	4	4	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0		
100	1	3	6	8	6	6	4	4	4	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0		
115	0	2	4	8	6	6	4	4	3	3	2	2	1	0	0	0	0	0	0	0	0	4/0	250	300			
130	0	1	4	8	6	6	4	3	3	2	2	1	0	0	0	0	0	0	0	0	4/0	250	300	300			
150	0	0	2	8	6	6	4	3	3	2	1	1	0	0	0	0	0	0	0	0	250	300	350	350			
175	4/0	0	2	6	6	4	4	3	2	1	1	0	0	0	0	0	0	0	0	0	300	350	400	400			
200	250	0	1	6	4	4	3	2	1	1	0	0	0	0	0	0	0	0	0	0	350	400	500	500			
225	300	4/0	0	6	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	400	500	500	600			
250	350	250	0	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	500	600	600	700			
275	400	300	0	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	500	600	700	800			
300	500	350	0	4	4	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	500	600	700	900			
325	600	400	4/0	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	500	600	700	750			
350	600	500	4/0	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	500	600	700	800			
375	700	500	250	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	600	700	800	900			
400	750	600	250	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	600	700	750	1M			

21. Minimum Allowable Size of Conductor

Aluminum up to 400 Amperes, 230-240 Volts, Single Phase, Based on 4% Voltage Drop

Load in Amperes	In Cable Conduit, Earth		Overhead in Air*		Length of Run in Feet																					
	Types R, T, TW	Types RH, RHW, THW	Bare & Covered Conductors		Compare size shown below with size shown to left of double line. Use the larger size.																					
			Single	Triplex	50	60	75	100	125	150	175	200	225	250	300	350	400	450	500	550	600	650	700	800	900	1000
5	12	12	10		12	12	12	12	12	12	12	12	12	12	10	10	10	10	10	8	8	8	8	8	8	6
7	12	12	10		12	12	12	12	12	12	12	12	12	10	10	10	8	8	8	8	6	6	6	6	6	6
10	12	12	10		12	12	12	12	12	12	10	10	10	8	8	8	6	6	6	6	6	6	4	4	4	4
15	12	12	10		12	12	12	10	10	10	8	8	8	6	6	6	4	4	4	4	4	4	3	3	2	2
20	10	10	10		12	12	10	10	8	8	8	8	6	6	6	4	4	4	4	3	3	3	3	2	2	1
25	10	10	10		12	12	10	10	8	8	6	6	6	4	4	4	3	3	2	2	2	2	1	1	0	0
30	8	8	10		12	12	10	8	8	6	6	6	4	4	4	3	3	2	2	2	1	1	0	0	0	0
35	6	8	10		12	10	10	8	6	6	6	4	4	4	3	3	2	2	1	1	1	0	0	0	0	0
40	6	8	10		10	10	8	6	6	6	4	4	4	3	3	2	2	1	1	0	0	0	0	0	0	0
45	4	6	10		10	10	8	6	5	6	4	4	4	3	2	2	1	1	0	0	0	0	0	0	0	0
50	4	6	8		10	8	6	6	4	4	4	4	3	2	2	1	1	0	0	0	0	0	0	0	0	0
60	2	4	6	6	8	8	6	4	4	4	3	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0
70	2	2(a)	6	4	8	8	6	6	4	4	3	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0
80	1	2(a)	6	4	8	6	6	4	4	3	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0
90	0	2(a)	4	2	8	6	6	4	4	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
100	0	1(a)	4	2	6	6	4	4	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
115	0	0(a)	2	1	6	6	4	4	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130	0	0(a)	2	0	6	4	4	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
150	4/0	0(a)	1	0	4	4	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
175	300	4/0(a)	0	0	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200	350	250	0	4/0	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
225	400	300	0		4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250	500	350	0		3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
275	600	500	4/0		3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300	700	500	250		2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
325	800	600	300		2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
350	900	700	300		2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
375	1M	700	350		1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400		900	350		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

EXAMPLE 1, 1a, 2

EXAMPLE 1: The residence has a computed load of 90-amps at 230V calculated according to NEC Section 220-30. This load is considered to be maximum demand. It is served from a meter pole 50 ft. from the house. Aluminum triplex will be used for the service drop. Voltage drop may be taken as 2%. Determine size of conductor for the service drop.

Referring to HO #2, Table 17 for 90-amp load, Column 5 shows No. 2 triplex. Column 6 shows No. 4 conductor will carry 90-amp 50 ft. within 2% voltage drop. Since the size of conductor in Column 5 is larger than that shown in Column 6, we will use the larger size.

EXAMPLE 1a: Assume same conditions as in Example 1 except that distance from meter pole to house is 150 ft. Column 5 of HO #2, Table 17 shows No. 2 as the minimum allowable size. Checking the size for 150-ft. run, we find No. 0 required. Since this is larger than the No. 2 triplex, we will specify the larger size.

EXAMPLE 2: The dairy barn has a demand load of 137-amp at 230 V. It is served from a meter pole 150 ft. from the barn. Individual aluminum conductors will be used for the service drop. See notes of Section 28 for discussion of spaced conductors versus aluminum triplex. Determine size of conductors. Refer to HO #2, Table 17. For 137-amp demand load, Column 4 shows that No. 1 conductors are the minimum size required to satisfy the NEC.

Refer to HO #2, Table 17. 137-amp, 150 ft. require No. 3/0 conductor. Since this is larger than the minimum size required we will specify No. 3/0.

EXAMPLE 3, 3a

EXAMPLE 3: Assume the dairy barn and the shop are served from a meter pole. Voltage drop from meter pole to either buildings is to be 2%. Use HO #2, Table 17 for 2% voltage drop.

Distribution pole to shop; computed demand, 71-amp. This requires No. 6 conductors, single or No. 4 triplex, as minimum.

Distribution pole to barn; maximum demand of 137-amp. This requires No. 1 single conductors or 2/0 triplex as minimum.

From the meter pole to distribution pole, the sum of the demands is 208-amp. We must determine the combined demand load of the two buildings.

To compute the combined demand of the dairy barn and shop, we can apply the same formula from NEC Section 220-40 as in HO #3, Example 2 just mentioned. Most of the shop loads would be intermittent and would have diversity with respect to the dairy barn loads. The shop heater would not be running at the time of year when hay equipment is in operation, nor is it likely the welder would be in use during chore time. The loads operating without diversity would be the same as for HO #3, Example 2. For the total 208-amp of demand load, we would compute as follows:

Loads operating without diversity	= 98-amp, 230V
Next 60-amp at 50% demand factor	= 30-amp, 230V
Remaining 50-amp at 25%	= 13-amp, 230V
Computed maximum demand	= <u>141-amp, 230V</u>

Refer to HO #2, Table 17. This load requires No. 1 conductors as minimum for 75 ft. and 2% voltage drop. No. 2/0 conductors are required if triplex is used.

Therefore, our design calls for No. 2/0 from meter pole to distribution pole; No. 2/0 from distribution pole to barn and No. 4 from distribution pole to shop.

EXAMPLE 3a: A feeder from dairy barn service entrance to milk house is 70 ft. long and serves the following loads:

Milk cooler, 3-hp, 17-amp x 1.25	= 21-amp, 230V
Milk cooler agitator, 1/6-hp	= 2.2-amp, 230V
Water heater, 1.5kW.	= 6.5-amp, 230V
Milk house heater, 1.5kW.	= 6.5-amp, 230V
Tank truck pump outlet, 1 1/2-hp	= 10.0-amp, 230V
	<u>46.2-amp, 230V</u>

Refer to HO #2, Table 16. For a 50-amp load, column 2 shows that No. 6 cable is minimum. Continuing across (right) to the column for a 75-ft. run, we find that No. 6 will also satisfy voltage drop requirement.

Several types of underground feeder and branch-circuit conductors are available in copper and aluminum. Identified as UF, USE, and URD.

COMPUTING FARM LOADS NEC

220-40. Farm Loads - Buildings and Other Loads.

(a) Dwelling Unit. The feeder or service load of a farm dwelling unit shall be computed in accordance with the provisions for dwellings in Part B or C of this article.

(b) Other Than Dwelling Unit. For each farm building or load supplied by two or more branch circuits the load for feeders, service-entrance conductors, and service equipment shall be computed in accordance with demand factors not less than indicated in Table 220-40.

See Section 230-21 for overhead conductors from a pole to a building or other structure.

Table 220-40

Method for Computing Farm Loads for Other Than Dwelling Unit

Ampere Load at 230 Volts	Demand Factor Percent
Loads expected to operate without diversity, but not less than 125 percent full-load current of the largest motor and not less than the first 60-amperes of load	
	100
Next 60-amperes of all other loads	50
Remainder of other load	25

220-41. Farm Loads - Total. The total load of the farm for service-entrance conductors and service equipment shall be computed in accordance with the farm dwelling unit load and demand factors specified in Table 220-41. Where this is equipment in two or more farm equipment buildings or for loads having the same function, such loads shall be computed in accordance with Table 220-40 and may be combined as a single load in Table 220-41 for computing the total load.

See Section 230-21 for overhead conductors from a pole to a building or other structure.

Table 220-41

Method for Computing Total Farm Load

Individual Loads Computed in Accordance with Table 220-40	Demand Factor Percent
Largest load	100
Second largest load	75
Third largest load	65
Remaining loads	50

To this total load, add the load of the farm dwelling unit computed in accordance with Part B or C of this article.

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370

FEEDER LOAD NEC

HO-6

220-22. Feeder Neutral Load. The feeder neutral load shall be the maximum unbalance of the load determined by this article. The maximum unbalance load shall be the maximum connected load between the neutral and any one ungrounded conductor, except that the load thus obtained shall be multiplied by 140 percent for 5-wire, 2-phase systems. For a feeder supplying household electric ranges, wall-mounted ovens, and counter-mounted cooking units, the maximum unbalanced load shall be considered as 70 percent of the load on the ungrounded conductors, as determined in accordance with Table 220-19. For 3-wire DC or single-phase AC, 4-wire, 3-phase, and 5-wire, 2-phase systems, a further demand factor of 70 percent shall be permitted for that portion of the unbalanced load in excess of 200 amperes. There shall be no reduction of the neutral capacity for that portion of the load which consists of electric-discharge lighting.

See Examples 1, 1(a), 1(b), 1(c), 2, 3, 4, and 5, Chapter 9.

Table 220-19. Demand Loads for Household Electric Ranges, Wall-Mounted Ovens, Counter-Mounted Cooking Units, and Other Household Cooking Appliances over 1 1/4 kW Rating. Column A to be used in all cases except as otherwise permitted in Note 3 below.

NUMBER OF APPLIANCES	Maximum Demand (See Notes) COLUMN A (Not over 12 kW Rating)	COLUMN B (Less than 3 1/2 kW Rating)	Demand Factors Percent (See Note 3) COLUMN C (3 1/2 kW to 3 3/4 kW Rating)
1	8 kW	80PERCENT	80PERCENT
2	11 kW	75	65
3	14 kW	70	55
4	17 kW	66	50
5	20 kW	62	45
6	21 kW	59	43
7	22 kW	56	40
8	23 kW	53	36
9	24 kW	51	35
10	25 kW	49	34
11	26 kW	47	32
12	27 kW	45	32
13	28 kW	43	32
14	29 kW	41	32
15	30 kW	40	32
16	31 kW	39	28
17	32 kW	38	28
18	33 kW	37	28
19	34 kW	36	28
20	35 kW	35	28
21	36 kW	34	26
22	37 kW	33	26
23	38 kW	32	26
24	39 kW	31	26
25	40 kW	30	26
26-30	15 kW plus 1 kW	30	24
31-40	for each range	30	22
41-50	25 kW plus 3/4	30	20
51-60	kW for each	30	18
61 & over	range	30PERCENT	16PERCENT

371

Note 1. Over 12 kW through 27 kW ranges all of same rating. For ranges individually rated more than 12 kW but not more than 27 kW, the maximum demand in Column A shall be increased 5 percent for each additional kW of rating or major fraction thereof by which the rating of individual ranges exceeds 12 kW.

Note 2. Over 12 kW through 27 kW ranges of *unequal ratings*. For ranges individually rated more than 12 kW and of different ratings but none exceeding 27 kW an average value of rating shall be computed by adding together the ratings of all ranges to obtain the total connected load (using 12 kW for any range rated less than 12 kW) and dividing the total number of ranges; and then the maximum demand in Column A shall be increased 5 percent for each kW or major fraction thereof by which this average value exceeds 12 kW.

Note 3. Over 1 $\frac{3}{4}$ kW through 8 $\frac{3}{4}$ kW. In lieu of the method provided in Column A, it shall be permissible to add the nameplate ratings of all ranges rated more than 1 $\frac{3}{4}$ kW but not more than 8 $\frac{3}{4}$ kW and multiply the sum by the demand factors specified in Column B or C for the given number of appliances.

Note 4. Branch-Circuit Load. It shall be permissible to compute the branch-circuit load for one range in accordance with Table 220-19. The branch-circuit load for one wall-mounted oven or one counter-mounted cooking unit shall be the nameplate rating of the appliance. The branch-circuit load for a counter-mounted cooking unit and not more than two wall-mounted ovens, all supplied from a single branch circuit and located in the same room, shall be computed by adding the nameplate rating of the individual appliances and treating this total as equivalent to one range.

Note 5. This table also applies to household cooking appliances rated over 1 $\frac{3}{4}$ kW and used in instructional programs.

See Table 220-20 for commercial cooking equipment.

Table 220-20 Feeder Demand Factors for Kitchen Equipment Other than Dwelling Unit(s)	
Number of Units of Equipment	Demand Factors Percent
1	100
2	100
3	90
4	80
5	70
6 & over	65

372

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 9 - How are the power lines connected to the buildings and how are farm buildings wired by the NEC?

Objective: By the conclusion of the unit, the student will be able to run electric lines to the agricultural structure, wire within the building safely, and be knowledgeable in the NEC requirements for agricultural buildings.

Study Questions:

1. What is the configuration at the pole?
2. How is the service entrance installed?
3. When would branch circuits be used on farm buildings?
4. What must be considered when wiring a barn?
5. What must be considered when wiring a hay barn?
6. How do you select your switches and receptacles?

References:

1. Wiring Simplified, H.P. Richter, Park Publications Inc., 1999 Shepard Road, St. Paul, MN 55116. Available through IML, UMC.
2. National Electric Code 1978.

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 9 - How are the power lines connected to the buildings and how are farm buildings wired by the NEC?

TEACHING PROCEDURE

- A. Review the rules of thumb for wiring, terms of electricity.
- B. Motivation - How many of you have seen a barn burn to the ground because of faulty wiring? Have you seen a dust explosion?
- C. Assignment - Check the wiring at home to see if it meets the National Code standards.
- D. Supervised Study
- E. Discussion
 1. When tapping off the main pole on the farmstead, care must be taken to be sure the system is properly grounded and the wire configuration is known.

What is the configuration at the pole?

- 1) There are three wires from the power line end at the top of the pole. Check with the power company as to the location of the neutral wire in the configuration. It can be either in the top or middle of the wire set.
- 2) At the pole is where the power is routed to the electric meter. There are two methods used to access the power. They are:
 - a) Single stacking, which is running the wires down the pole in a conduit and then through the meter and out to the building
 - b) Double stacking, which is using separate conduits for each trip
- 3) From the pole the neutral wire is grounded to the earth. This is accomplished by running a wire from the neutral directly to a ground rod (or 2 ground rods 6 ft. apart) buried in the earth.
- 4) Be sure to install insulators that can withstand any weather problems that might be encountered. Two racks of insulators are needed for the job, one set for incoming and one set for outgoing power. The racks should be anchored with heavy lag screws and at least one through-bolt for each rack.

2. In part one, the amperage of the service entrance was determined and the wires have been run from the pole to the building. At this point the service entrance must be identified and installed.

How is the service entrance installed?

- 1) When planning the service entrance several factors must be considered during the planning process. These should all be in the master plan.
- 2) Service entrance wire size is in the NEC, pp. 230-241.
- 3) Two or 3-wire entrance
 - a) In a 2-wire system only 120 volts is available.
 - b) In a 3-wire system, both 120 and 240 volts are available. It consists of 2 120-volt lines and neutral grounding at the pole.
- 4) Service ratings are either switches or breakers.
 - a) Service switches are rated at 30, 60, 100 or 200 amps.
 - b) Breakers are rated at 30, 40, 50, 60, 70, 100, 125, 150, 175 and 200-amps.
 - c) To find the wattage available multiply the amperage rating by the voltage.
- 5) When deciding to use breakers or fuses, consider the ease of resetting a breaker and the overload (temporary) capacity.
- 6) Solid Neutral - never interrupt the incoming neutral wire with a fuse or breaker.
- 7) Neutral and Grounding Busbar - cabinets of equipment containing breakers or fuses will contain a copper grounding busbar, on which are installed several large solderless connectors for the heavy incoming neutral wire and the ground wire, plus as many small connectors or terminal screws as needed, one for the grounded wire of each 120-volt circuit.
- 8) Protection of the system begins with a main breaker usually 2-pole 100-amps or larger that will protect the electrical system.
- 9) In this system there are more breakers to protect the individual circuits. Single-pole for 120 volts and double-pole for 240 volts are installed for each branch circuit, and connected to the neutral-ground busbar.
- 10) The NEC requires that the service entrance equipment be located as close as practical to the point where the wires enter the house. Try to locate the service box as near as possible to the high load equipment to reduce expensive wire runs and electric loss.

- 11) Proper grounding by connection to a water pipe or driven copper rod is important for protecting the service box and branch circuits.
 - 12) Try to locate the water pump fuse on a separate circuit so it will continue to run if the main box is knocked out by fire.
3. Stressing planning again, we must plan for enough circuits to provide the power we need now and in the future.

When would branch circuits be used in farm buildings?

- 1) Cost per circuit in the panel box is lower if extras are installed when the building is constructed. Remember, the type of building will determine the number of branch circuits needed.
 - 2) If the building only needs lights, like a machine shed, only 2 circuits of 120 volts would be necessary in the panel.
 - 3) For a well equipped farm shop, farm circuits will be needed with 120/240 service. A well equipped dairy would require a dozen circuits, and a confinement feeding operation would require 6 or more circuits to provide sufficient power for the equipment.
 - 4) Measure the wattage carefully for each circuit to prevent overloading troubles.
 - 5) Install circuit breakers wherever possible to ease reset problems and costs.
4. Barns have special characteristics and problems that require consideration when wiring is installed. Safety factors are a must and have to be carefully considered.

What must be considered when wiring a barn?

- 1) Barns are naturally damp, especially in the wintertime, and often lack sufficient ventilation to limit moisture buildup. It is recommended that type NCM or UF cable with nonmetallic boxes be used because of the water resistance.
- 2) Care must be taken to prevent injury from mechanical sources. The electric cables should be protected from crushing or puncturing by running the cables along the side of the beam; then along the side of the joist to where the light or fixture is to be installed.
- 3) Do not skimp on lighting. Preferred is a light per stall and should be installed flush with the bottom of the joists.
- 4) Switches should be located where they are most accessible and at all entrances to the building.

- They should be mounted at elbow height as they can be operated even if both hands are full.
- 5) Receptacles should be dust and watertight and made of corrosion-resistant material. Ground-fault interrupter circuits would be best or use properly grounded outlets. Install enough to eliminate the need for extension cords.
 - 6) Locate switches, receptacles, and lights out of the reach of livestock because of the danger of shock or fire if an electrical outlet is contacted.
5. Special considerations go into a barn used to store hay. Remember the grain storage dust explosions?

What must be considered when wiring a hay barn?

- 1) The biggest consideration in a hay barn is lighting. The electrical code specifies the following in Section 547-6:
 - a) Lighting fixtures shall be installed to minimize the entrance of dust, foreign matter, moisture and corrosive material.
 - b) Any lighting fixture that may be exposed to physical damage shall be protected by a suitable guard.
 - c) A fixture that may be exposed to water from condensation and/or building cleansing water or solution shall be watertight.
- 2) A switch with a pilot light would be helpful to see if the lights are on.
- 3) The dust produced by the hay is highly flammable.
 - a) Just the split second it takes for the filament to melt after exposure to air could set off an explosion or start a fire.
 - b) "Vapor proof" fixtures should be used to protect from accidents.
 - c) The glass, tightly-sealed fixtures are in a metal cage enclosing the light bulb.
- 4) In hay barns The NEC and inspectors require extra protection for the cables. Running the wires inside of conduit or running the wires inside the wall protected by sheathing is preferred.
- 5) Code Section 250-33 requires grounding isolated sections of conduit in most cases--and in all cases if over 25 ft. long. This can be done by connecting the ground wire from the service box cable to the conduit.

6. An important part of farm wiring is selecting the proper switches and receptacles for the job.

How do you select your switches and receptacles?

- 1) The NEC says that switches, circuit breakers, motor controllers, fuses, push buttons, relays and similar devices shall be provided with a weatherproof, corrosion-resistant enclosure designed to minimize the entrance of dust, water and corrosive elements, and shall be equipped with a telescoping or close-fitting cover.
- 2) Switches and receptacles used outdoors are recommended for farm wiring because of their durability.

F. Summary

Problems occur in farm buildings if care is not taken to protect the structures from overloads and dust explosions. Proper planning and the use of quality components will make a safer structure.

G. Evaluation

Answers to Exam

1. F
2. T
3. F
4. F
5. T
6. T
7. T
8. F

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 9 - How are the power lines connected to the buildings and how are farm buildings wired by the NEC.

EXAM

True-False

- T F 1. If spans of wire run over 50 feet, number 10 feeder wire can be used.
- T F 2. The neutral wire should be grounded at the pole.
- T F 3. Incoming 3-wire power consists of 2 240-volt lines and a neutral wire.
- T F 4. Always fuse the neutral wire to prevent electric shock.
- T F 5. Nonmetallic boxes should be used in barns because of the dampness.
- T F 6. Dust explosions can occur in a hayloft.
- T F 7. "Vapor-proof" lights should be used in a hayloft.
- T F 8. In a barn structure the wires may run uncovered (no conduit).

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 10 - How is the wiring connected to the service entrance panel (SEP)?

Objective: By the end of the lesson, the student will be able to connect the drop wires and branch circuit wires to the SEP.

Study Questions:

1. What are the parts of the SEP?
2. What are some good wiring practices to follow when wiring the panel?
3. What is the procedure for connecting the service entrance conductors to the SEP?
4. How is the ground system installed for the SEP?
5. How are the 120-volt branch circuits connected to the SEP?
6. How are the 240-volt individual circuits connected to the SEP?

References:

1. Electrical Wiring by AAVIM, available through IML, UMC. \$7.50.
2. National Electrical Code 1978. Available through IML, UMC.
3. Wiring Simplified, H.P. Ritcher, Park Publications Inc., 1999 Shepard Road, St. Paul, MN 55116. Available through IML, UMC.
4. Practical Farm Wiring Demonstrations, by Curtis Weston.

Transparencies:

1. TM #1: Panel Parts
2. TM #2: Wired Panel
3. TM #3: Ground System
4. TM #4: Wired Panel 120/240V

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 10 - How is the wiring connected to the service entrance panel?

TEACHING PROCEDURES

- A. Review the wiring of branch circuits, the planning of service entrance size, and setting the service drop.
- B. Motivation - Where is the service entrance located in your home? Could you rewire or run another circuit to it? How many leads per circuit must be connected?
- C. Assignment - Diagram the SEP in each student's home tracing the wires for each branch circuit. Also check the grounding of circuits.
- D. Supervised Study - Evaluate the circuits in the shop panel as a class or individually.
Practical Farm Wiring Demonstrations,
- E. Discussion Sections 1: A, E
 1. The service entrance panel is the heart of the electrical distribution system. In earlier lessons we discussed the size of the panels, i.e., 30-amp panel if load is under 30, 60-amp panel if load is between 30 and 60-amps, and over 60-amps use 100-amp panels or larger. All are basically similar so 100-amp panels will be discussed in this lesson. See TM #1.

What are the parts of the SEP?

- 1) Main disconnect
 - 2) Circuit breakers or fuses
 - 3) Space for additional circuits
 - 4) Neutral bar and grounding terminal
 - 5) Cabinet
2. When connecting all the wires to the SEP be sure to follow proper wiring practices. Some problems could arise if the box is not wired correctly.

What are some good wiring practices to follow when wiring the panel?

- 1) Problems with overheating in panels
- 2) Can reduce heat buildup by wiring neatly and orderly.
- 3) Cut off excess wire length, straight runs.
- 4) Make tight connections without excessive bare wire showing.
- 5) Mount neutral bar in most convenient location in the box.

3. From the service drop three wires will usually enter the building and SEP. They are two 120-volt hot conductors and a neutral. It is very important to have solid connections between these wires and the SEP. See TM #2.

What is the procedure for connecting the service entrance conductors to the SEP?

- 1) Always check to see if the power is off.
 - 2) Connect the two hot conductors.
 - a) Can be both black wires or one red, one black
 - b) Cut off excess length.
 - c) Insert wire into connectors on main breaker. (disconnect)
 - d) Tighten securely, usually held by hexagonal screws requiring an "Allen" wrench
 - e) If aluminum is used be sure to coat both with inhibitor paste and check box for Al-Cu markings on terminals.
 - 3) Connect the neutral wire to the neutral bar using the procedures in number 2.
 - 4) Ground the panel cabinet with a bonding strap connecting neutral bar to the box.
4. A critical part of the SEP installation is the grounding system. The NEC has specific rules for setting the system up. See TM #3.

How is the ground system installed for the SEP?

- 1) If the water pipe is to be used, the NEC requires one or more additional electrodes.
- 2) To determine the size of the grounding conductor use the size of the largest service entrance conductor and Table 250-94 of the NEC.
- 3) The grounding electrode conductor must be copper, aluminum or copper-clad aluminum.
 - a) S-E conductor 2 or smaller copper or 0 or smaller Al used 8 Cu or 6 Al
 - b) S-E conductor 1 or 0 Cu, or 2/0 or 3/0 Al use 6 Cu or 4 Al
 - c) S-E conductor 2/0 or 3/0 Cu, or 4/0 or 250 MCM Al use 4 Cu or 2 Al
 - d) S-E conductor over 3/0 thru 350 MCM, or over 250 MCM thru 500 MCM use 2 Cu or 0 Al
- 4) Place a jumper cable around the water meter or any plastic pipe.
- 5) Bonded electrode systems (4 linked systems)
 - a) Four-electrode bonded systems
 - i) Metal underground water pipe, 10 feet of earth contact
 - ii) Metal frame of building

- iii) Electrode in 2 inches of concrete at base of footing
 - iv) Ground ring greater than number 2 AWG encircling building 2 1/2 feet deep. (These are optimum systems not required)
 - b) Three-electrode bonded systems
 - i) Water pipe
 - ii) Electrode in concrete
 - iii) Ground ring
- 6) The grounding conductor is attached to the neutral bar by a screw clamp.
- 7) Connect to water pipe with a clamp that will bite into the pipe and clamp to the outside electrode.

5. Once service has been established we can start installing the circuit breakers of the 120-volt circuits. Plan the location of each circuit in the box before starting.

How are the 120-volt branch circuits connected to the SEP?

- 1) Connect the neutral and ground wires to the neutral bar.
 - a) Strip off enough insulation to have good contact.
 - b) Tighten screws firmly, one wire per screw.
 - 2) Insert black wire under terminal screw of the circuit breaker and tighten.
 - 3) Insert breaker into slot in the SEP and clip into place.
 - 4) Be sure to remove excess wire to have a "cleaner" box.
6. The larger circuits will have more than one breaker. For 240 volt a double-pole breaker is used in most cases.

How are the 240-volt individual circuits connected to the SEP?

- 1) Connect black wire to one terminal screw of the double-pole breaker.
- 2) Connect the white wire to the second terminal screw; mark with black tape at the end of the wire.
- 3) Connect grounding wire to neutral bar.

F. Summary

Wiring the SEP is crucial to the successful wiring of a structure. Be sure to have solid connections and a small manicured box without a lot of excess wires.

G. Evaluation

Answers to Exam

1.
 - a. Main disconnect - shut down all circuits
 - b. Breakers or fuses shut down individual circuits.
 - c. Space - allows for expansion
 - d. Neutral bar - safety
 - e. Cabinet - protects breakers, holds all together
2. Main disconnect
3.
 - a. Copper
 - b. Aluminum
 - c. Copper-clad aluminum
4. F
5. 3, 1, 3, 2

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 10 - How is the wiring connected to the service entrance panel?

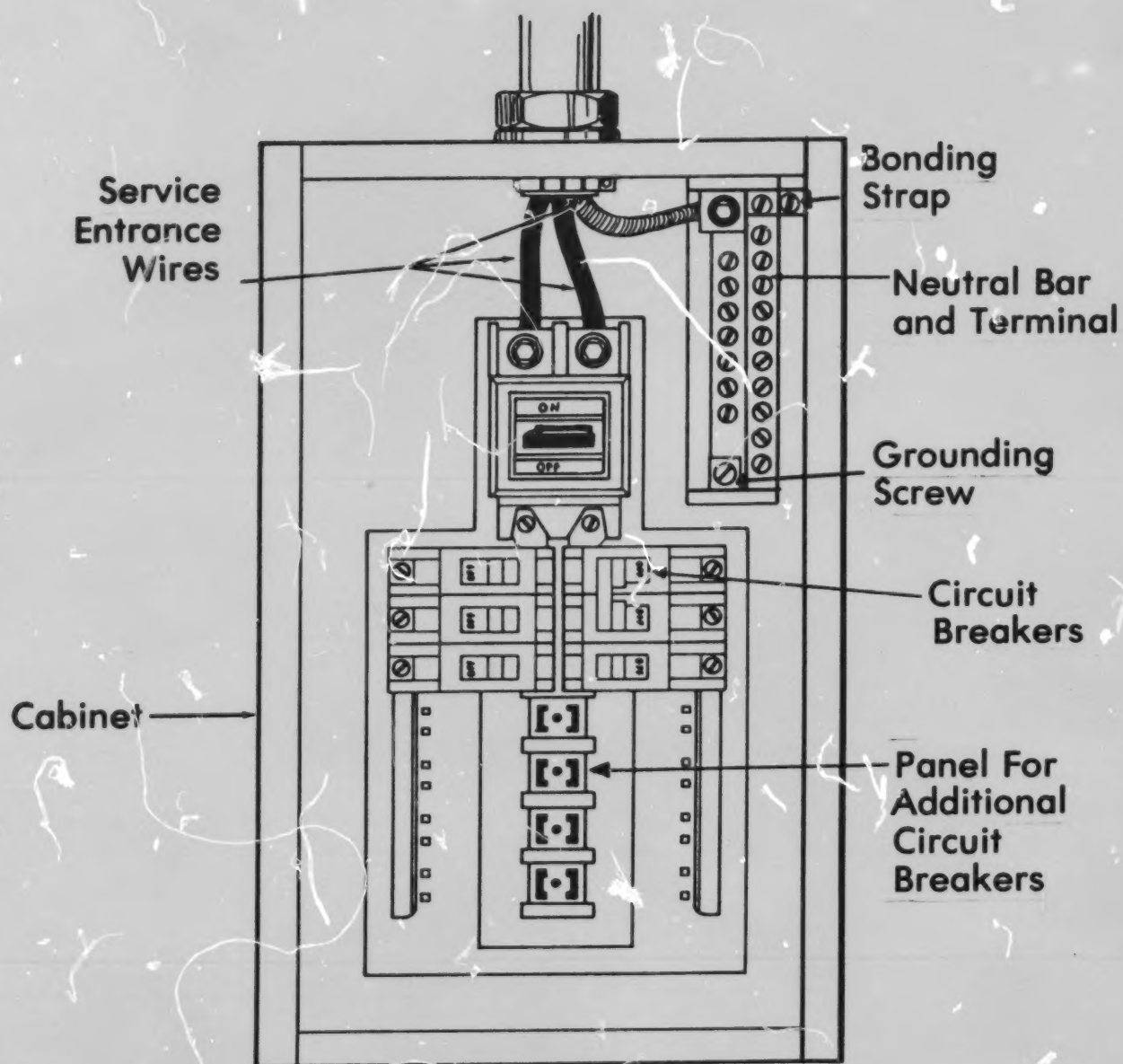
EXAM

1. Name the parts and function of the service entrance panel.
 - a.
 - b.
 - c.
 - d.
 - e.
2. Where are the two hot service drop wires connected in the panel?
3. What are the three types of wire used in service drop wires?
 - a.
 - b.
 - c.
- T F 4. A water pipe ground is enough to protect the service entrance panel.

Circle the correct answer within each set of parenthesis.

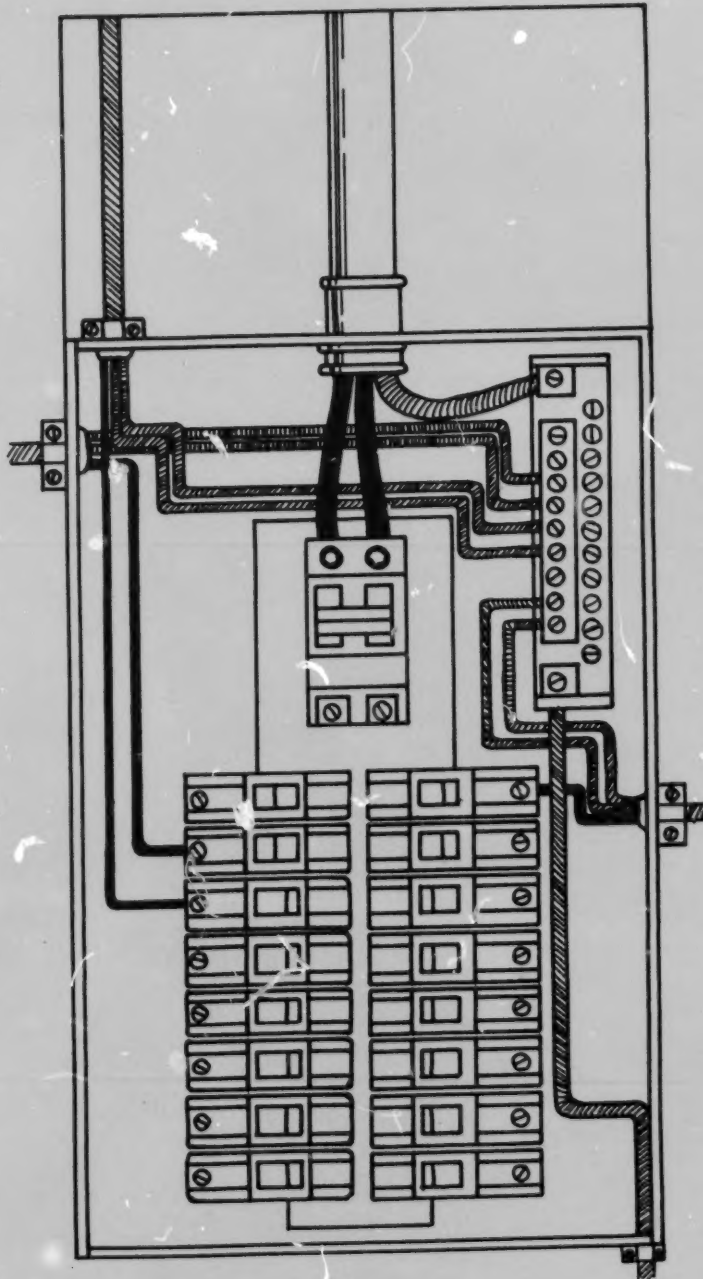
5. A 120-volt circuit has (1, 2, or 3) wires and uses (1, 2, or 3) circuit breakers and a 240-volt circuit has (1, 2, 3) wires and uses (1, 2, or 3) circuit breakers.

Panel Parts



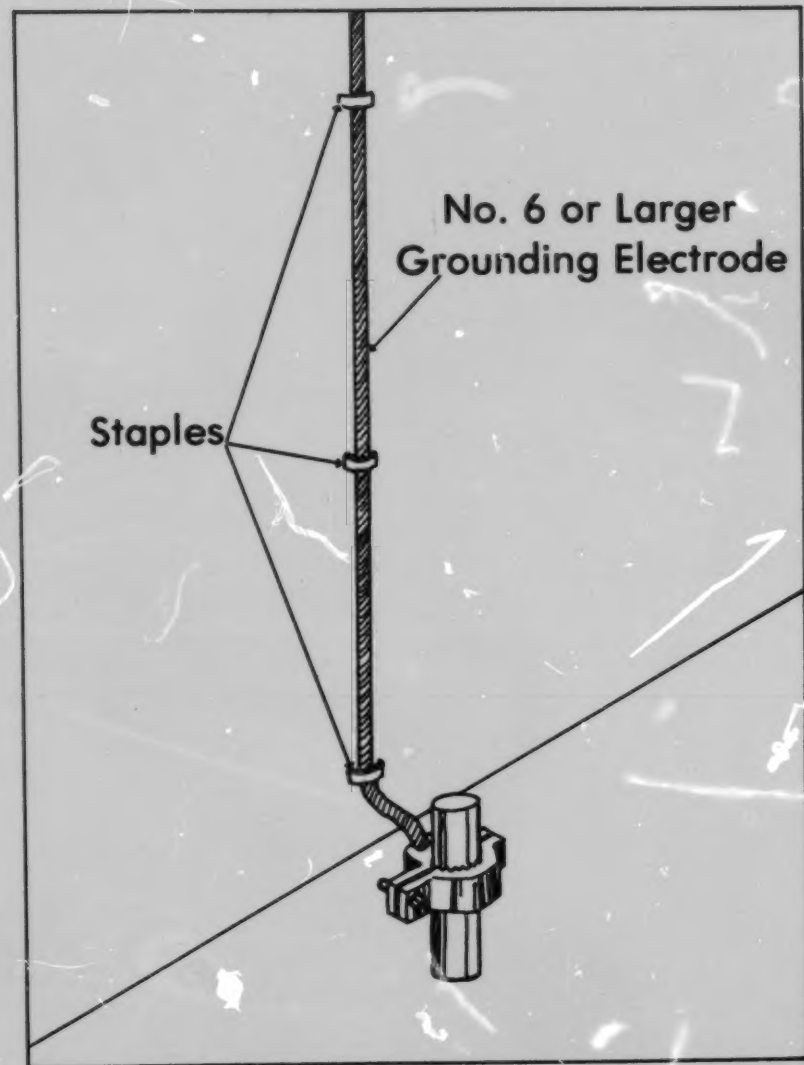
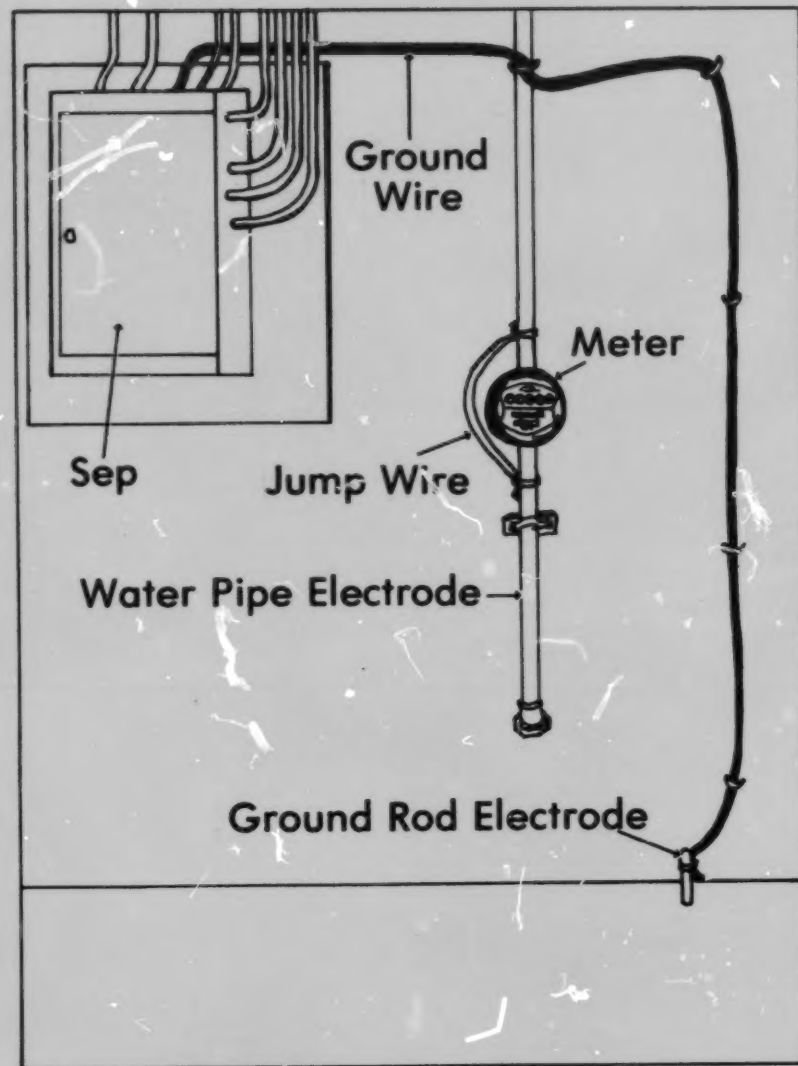
TM 2

Wired Panel



387

Ground System

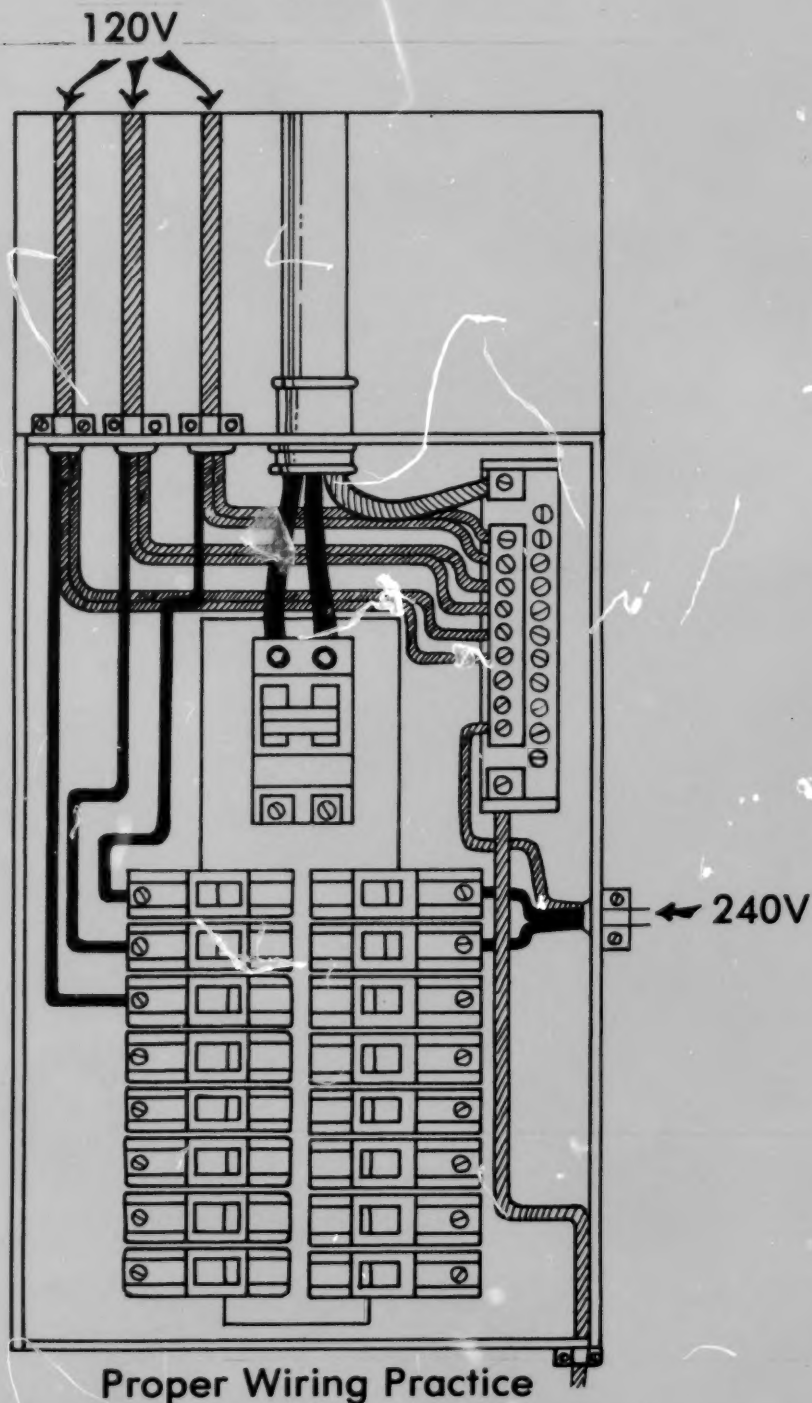


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TM-3

Wired Panel 120/240 V

TM-4



UNIT - ELECTRICAL WORK ON THE FARM

Lesson 11 - How are wires run from the service entrance panel to the outlets?

Objective: By the conclusion of the lesson, the student will be able to correctly run wires from the service entrance panel to the outlets of each circuit.

Study Questions:

1. Where do you locate the service entrance panel?
2. How do you determine the route to each circuit?
3. How are the wires run through the building?

References:

1. Electrical Wiring, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211. \$7.50.
2. National Electrical Code 1978. Available through IML, UMC.
3. Wiring Simplified, H.P. Richter. Park Publications Inc., 1929 Shepard Road, St. Paul, MN 55115. Available through IML, UMC.
4. Practical Farm Wiring Demonstrations, by Curtis Weston.

Transparencies:

1. TM #1: Floor Plan
2. TM #2: Wiring Plan
3. TM #3: Labeling
4. TM #4: Ceiling Runs
5. TM #5: Wires to Outlets

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 11 - How are wires run from the service entrance panel to the outlets?

TEACHING PROCEDURE

- A. Review planning for electrical load and farm wire planning.
- B. Motivation - Does it matter where the wires for each circuit go in the framing? Is protection from the elements needed for most wire types?
- C. Assignment - Trace the electrical circuits in a major building on each student's farm. Have each student diagram the circuits.
- D. Supervised Study - Discuss the plans drawn in the assignment. Look for possible overloads in a circuit.
Practical Farm Wiring Demonstrations,
Sections 1: A, E; 2: A; 3: A-E.
- E. Discussion

1. The service entrance panel (SEP) needs to be conveniently located for access in case of trouble and to shorter wire runs which can decrease voltage drop.

Where do you locate the service entrance panel?

- 1) Near the service drop (ask power supplier)
 - 2) Near high draw equipment to cut wire cost
 - 3) In a location easily accessible
2. At times the SEP may be located at the extreme end of a building to service the high draw equipment. So, accessibility to the power may be limited in some parts of the building.

How do you determine the route to each circuit?

- 1) There will be two main types of circuits.
 - a) General
 - b) Individual
- 2) General circuits 120 volts
 - a) Lighting
 - b) Small appliances
 - c) Convenience outlets
- 3) Individual usually 240 volts
 - a) Ranges
 - b) Electric motors
 - c) Dryers
 - d) Heaters
- 4) Make a diagram of the structure. See TM #1.

- a) Mark an entry point to the area served and the number of outlets on the circuit. (Add up the load to be sure sufficient amperage can be provided.)
- b) Repeat for each circuit. See TM #2.
- c) Plan each individual circuit.
- 5) Mount the boxes at each location and label by circuit, i.e., CL 1-1 for storage area light, CL 1-2 for garage light. See TM #3.
 - a) Include type of circuit light
 - b) Include number of circuit - one
 - c) Include number of outlets in circuit - one or two
- 3. When actually running the wires there are several rules and ways that will affect the wiring procedure.

How are the wires run through the building?

- 1) Farm building rules
 - a) Generally high moisture and corrosion
 - b) Use Type NMC wire or UF if NMC not available.
 - c) Expose as little as possible to moist conditions.
 - d) Use corrosion resistant materials wherever possible.
- 2) Limit the bending of wire to prevent insulation from cracking.
- 3) Run inside walls and ceilings to prevent physical damage.
- 4) Methods from SEP to start of circuit. See TM #4.
 - a) Ceiling run is best, no traffic can have moisture barrier.
 - b) Under floor is a problem if animals in building cause manure corrosion and physical damage. (Possible exception is to implant conduit in concrete.)
- 5) To run in walls-See TM #5.
 - a) Drill hole in center of stud.
 - b) Notch studs; then cover with steel plate.
 - c) Run along side of stud stapling to stud. (horizontal)
 - d) Notch the bottom of studs and patch through. (Less problems with installing insulation later.)
- 6) Run individual circuits as direct as possible.
- 7) Use as few splices as possible to prevent the possibility of system failure.
- 8) HIGH and DRY are watchwords when planning as well as PROTECTING.

F. Summary

A good wiring plan can prevent the overloading of circuits as well as provide a way to estimate wiring needs. The laying out within the building as well as on paper will save time and end in a higher quality product.

G. Evaluation

Answers to Exam

1. T
2. F
3.
 - a. Type of circuit
 - b. Circuit number
 - c. Outlet number
4. Any 2 of the following:
 - a. Corrosion
 - b. Physical damage
 - c. Repair case
5.
 - a. Notch in stud
 - b. Notch bottom of stud
 - c. Hole in center parallel to stud

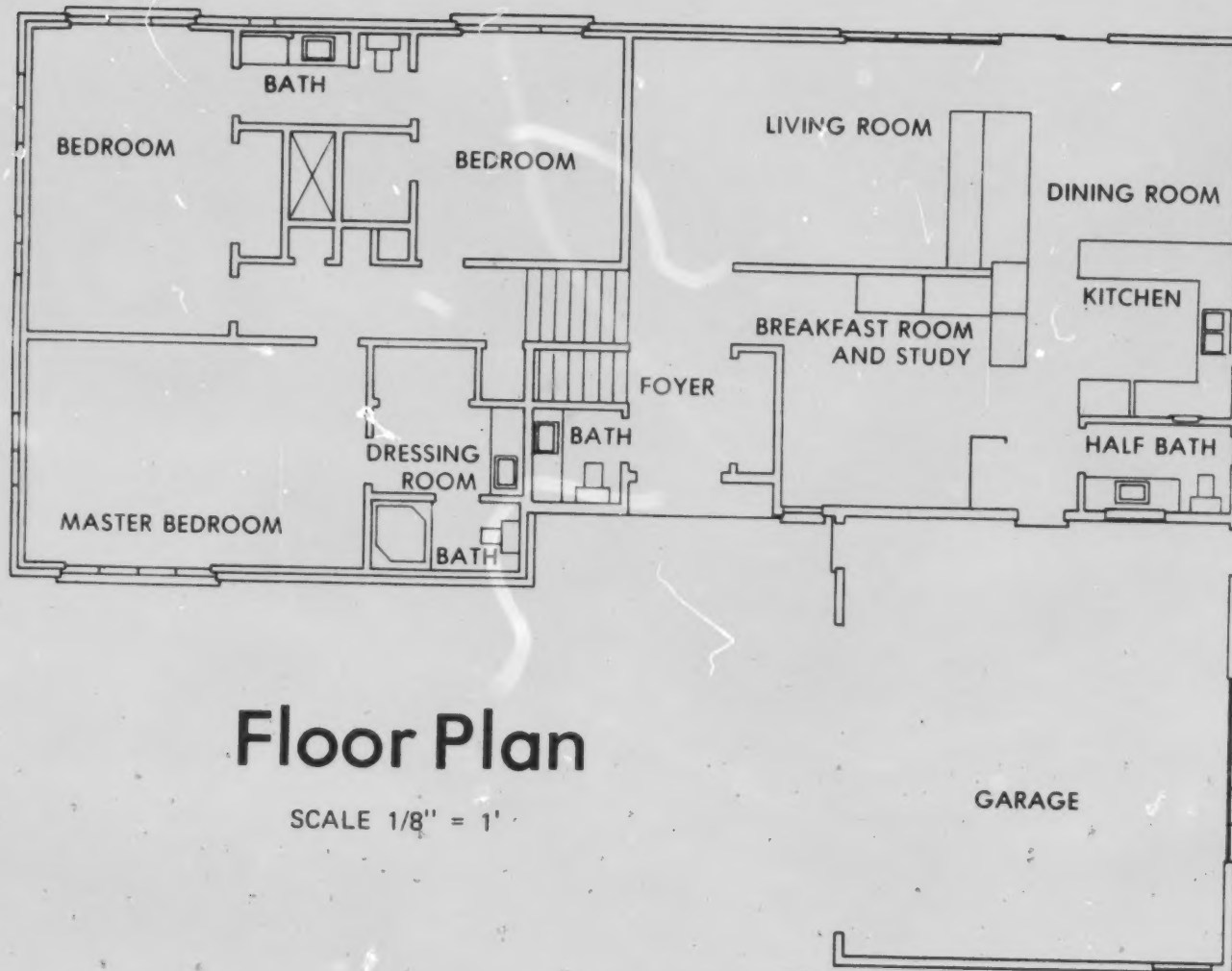
UNIT - ELECTRICAL WORK ON THE FARM

Lesson 11 - How are wires run from the service entrance panel to the outlets?

EXAM

- T F 1. The service entrance panel should be located near high draw equipment.
- T F 2. General circuits usually serve the electric motors on the farm 1/2-hp or more.
3. When labeling the location of each outlet be sure to include:
- a.
 - b.
 - c.
4. Two reasons for running wires overhead in a farm structure are:
- a.
 - b.
5. Name three methods for running wires inside walls.
- a.
 - b.
 - c.

535



Floor Plan

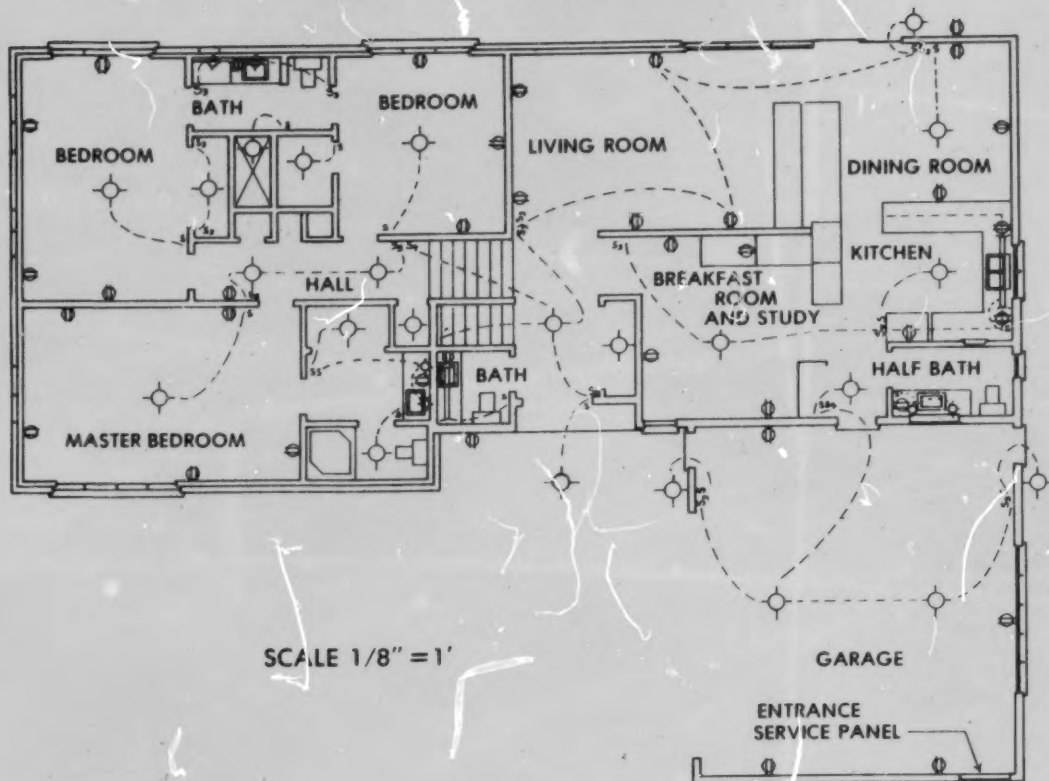
SCALE 1/8" = 1'

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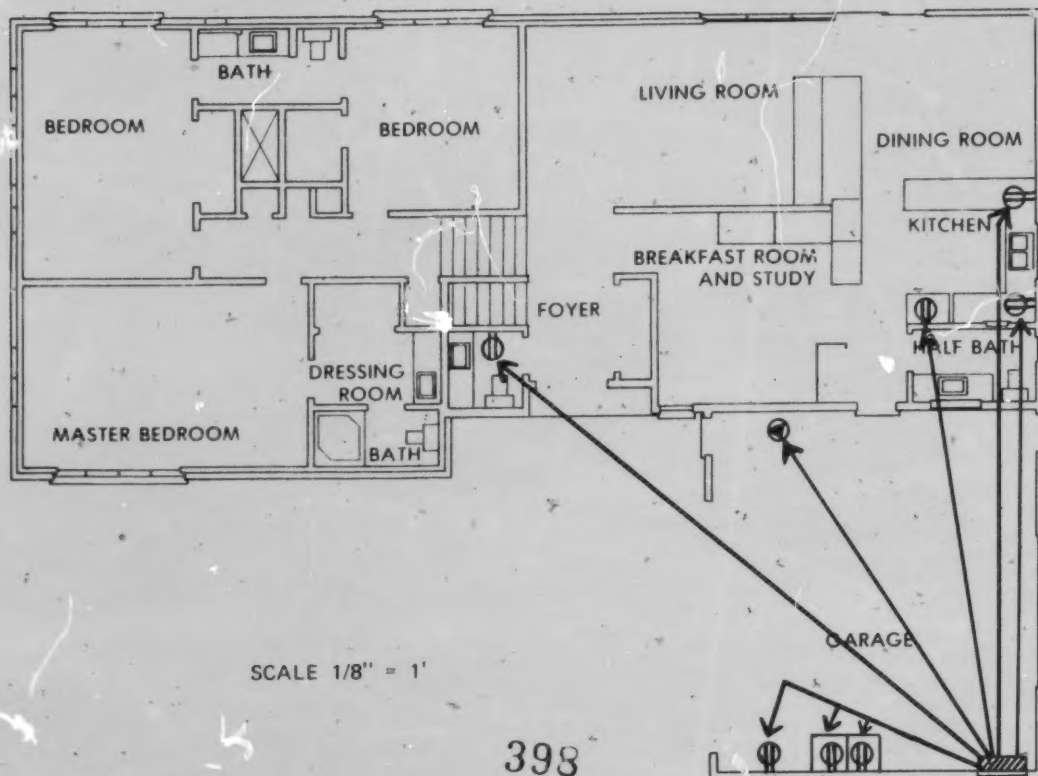
TM-1
397

Wiring Plan

TM-2



SCALE 1/8" = 1'

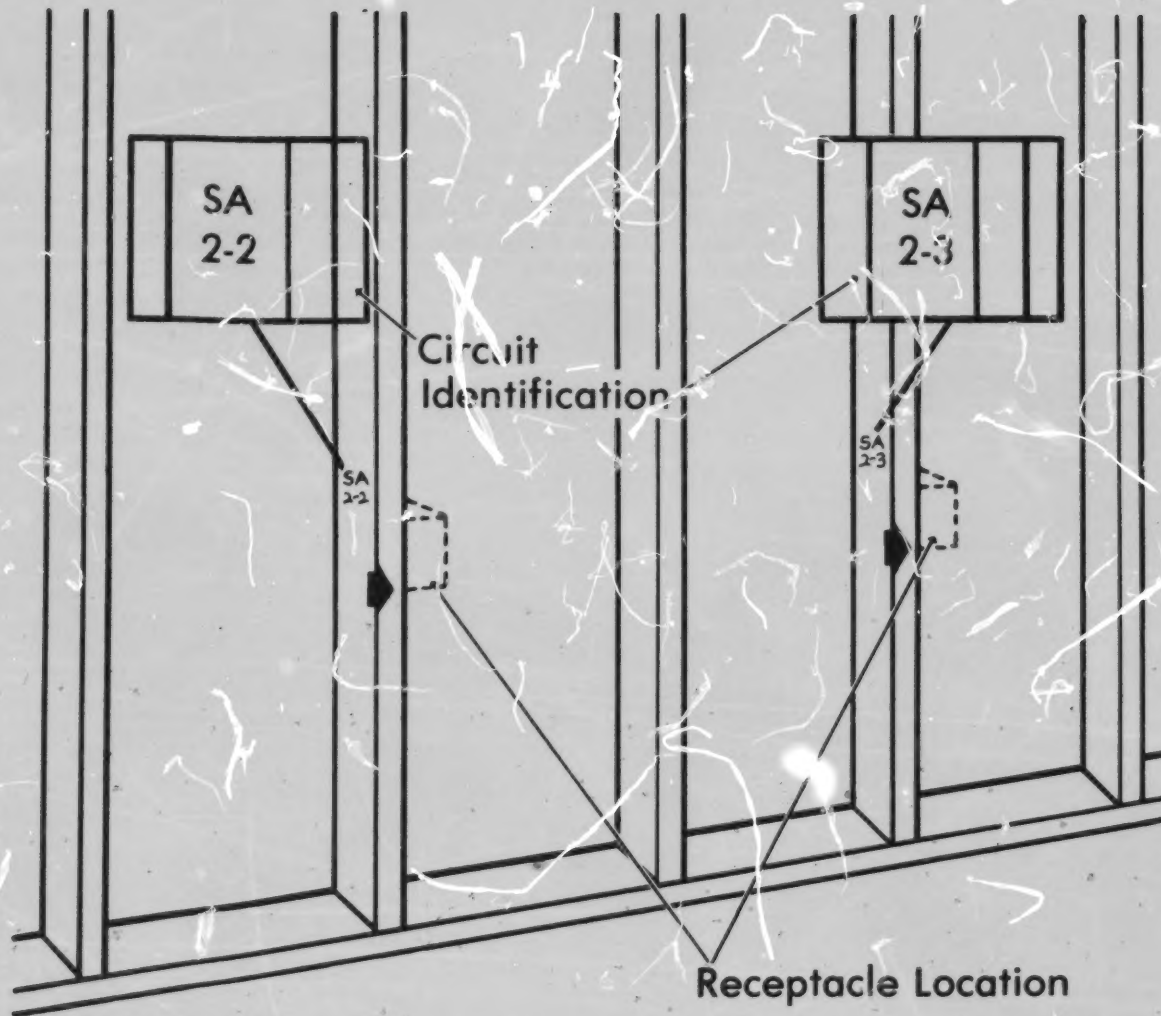


SCALE 1/8" = 1'

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537

Labeling

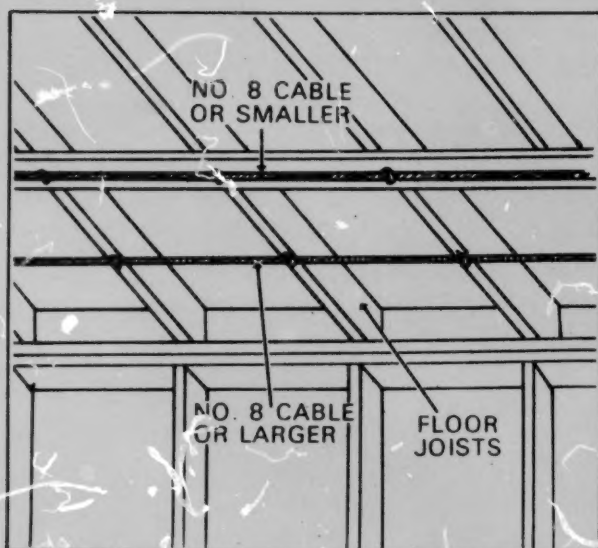


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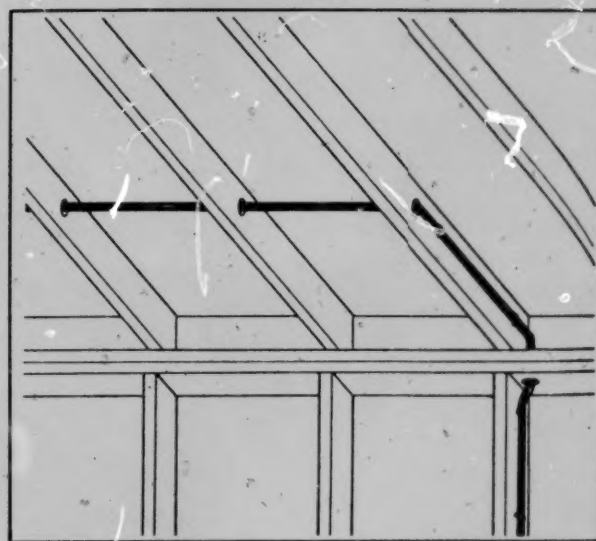
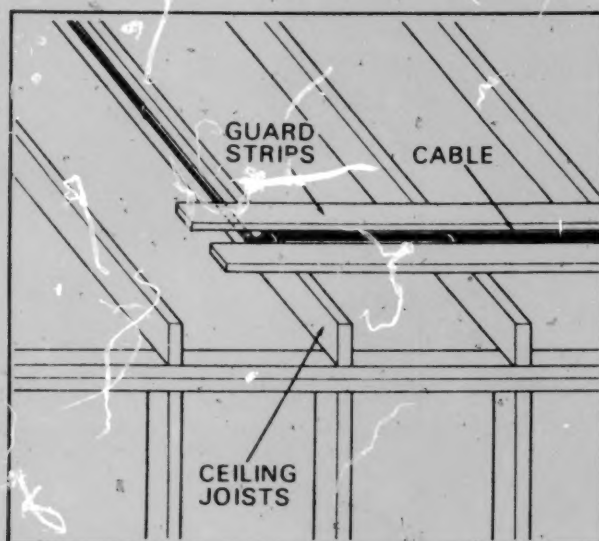
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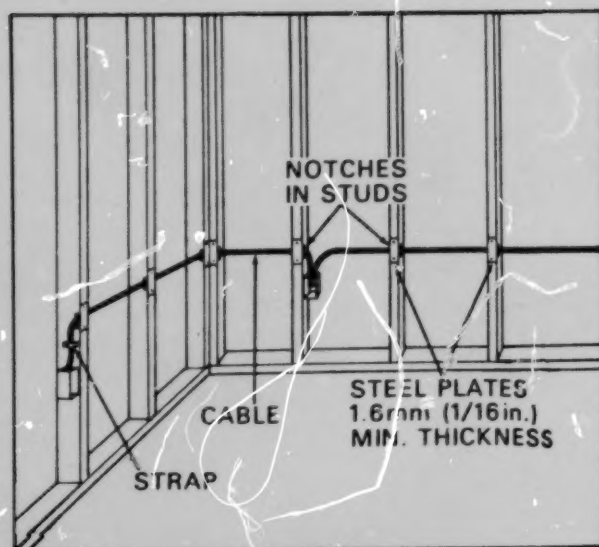
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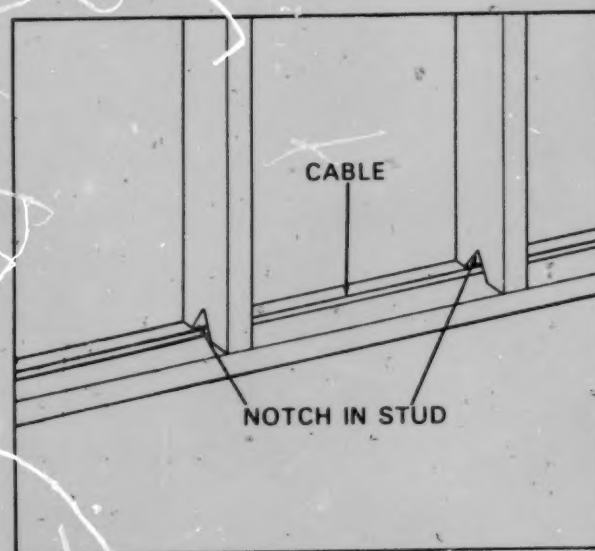
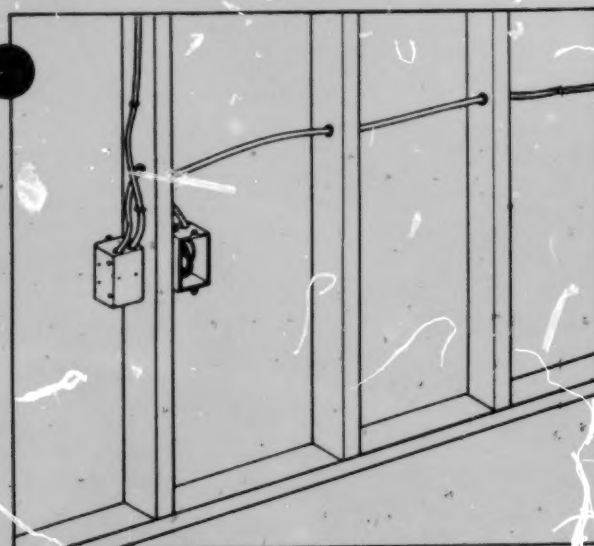


Ceiling Runs





Wires to Outlets



UNIT - ELECTRICAL WORK ON THE FARM

Lesson 12 - What are the principles of wiring switches and circuits?

Objective: By the conclusion of the lesson, the student will be able to wire junction boxes, simple light and receptacle circuits and splice wires.

Study Questions:

1. What tools are needed to wire a receptacle or light?
2. What is the function of a junction box?
3. What techniques are used when splicing wires?
4. How do you wire a light circuit?

References:

1. Mechanics in Agriculture, Lloyd Phipps, The Interstate.
2. National Electrical Code 1978. Available through IML, UMC.
3. Wiring Simplified, H.P. Richter, Park Publications Inc., 1999 Shepard Road, St. Paul, MN 55116. Available through IML, UMC.

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 12 - What are the principles of wiring switches and circuits?

TEACHING PROCEDURES

- A. Review the basic terminology, wire types and uses.
- B. Motivation - Have you ever tried to wire a light? How about a receptacle? Have you ever seen a short circuit from improper wiring?
- C. Assignment - Check the configuration of the wires or receptacles and lights for wiring sequence.
- D. Supervised Study
- E. Discussion
 1. Wiring a system with tools not designed for effective wiring practices, such as a pocketknife, slip-joint pliers, and a screwdriver, adds time, danger and hardship to the exercise.

What tools are needed to wire a receptacle or light?

- 1) They are grouped as cutters, benders, strippers, analyzers, etc.
- 2) Needle-nose pliers
 - a) For bending small bare wire
 - b) Reaching into boxes to retrieve wires
 - c) Helping generally by gripping wires when twisting
- 3) Lineman's pliers are flat-nosed with side cutters.
 - a) Good grippers
 - b) Multipurposed
- 4) Diagonal pliers are wire cutters.
- 5) Wire cutters, stripper correctly removes the insulation from wires without damaging the wire.
 - a) A pocketknife can dent or damage the conductor leaving a weak point in the wire.
- 6) Screwdrivers should be available in a set.
 - a) No one screwdriver can do every job.
 - b) The screwdriver must match the size of the screw to prevent damage.
- 7) Ammeter to check flow of current
- 8) Voltmeter to check for voltage drop in the system.
- 9) Ohmmeter is to check resistance to flow and to check to see if wiring is correctly attached.
Example: If the hot side of the plug is correctly attached to the hot wire.

2. When wiring circuits for efficient use, it is necessary at times to branch off a service entrance line. This is the function of the junction box.

What is the function of the junction box?

- 1) It is sometimes necessary to make a T connection when using cable.
 - a) If there is a long run
 - b) No convenient outlet from which to start the T branch
 - c) When this problem occurs an outlet box with solid-cover junction box can be used to make the connections.
 - d) Run the three or more ends of cable into the box through the punch out holes.
 - i) Splice black wires together, white wires together and grounding wires together.
 - ii) Cover the box with a cover.
 - e) Such junction boxes must always be located where permanently accessible to facilitate quick repairs.
 - 2) The NEC states that all boxes in which devices are installed where taps, joints, or terminal connections are made shall be dust and water tight and shall be made of corrosion-resistant material.
 - 3) Clamping the incoming wires securely at the entrance to the box will prevent the pulling apart of the splices.
 - 4) Ground all metallic boxes with the green wire from the input cable.
3. A key skill the electrical worker must master is the ability to splice wire properly.

What techniques are used when splicing wire?

- 1) The NEC states, "conductors shall be spliced or joined with splicing devices suitable for the use or by brazing, welding, or soldering with a fusible metal or alloy. Soldered splices shall be so spliced or joined as to be mechanically and electrically secure without solder and then soldered. All splices and joints and the free ends of conductors shall be covered with an insulation equivalent to that of the conductors or with an insulating device suitable for the purpose."

- 2) Western Union splice
 - a) Start with two bare ends of wire 3 inches in length
 - b) Cross the wires at about 1 1/2 inches; then twist the bare end around the other wire.
 - c) Solder (optional)
 - d) Tape with electrical (friction) tape protecting the bare wire from air.
 - 3) A tap or branch splice is used to draw power from existing lines.
 - a) Insulation is removed from the existing line, about 2 inches.
 - b) The tap wire is stripped about 3 inches.
 - c) Wrap the tap wire around the existing wire.
 - d) Solder and tape.
 - 4) A rat-tail splice is used when there is no strain on the wires.
 - a) There can be more than 2 wires.
 - b) Strip on the ends for about 3 inches.
 - c) The ends are twisted together.
 - d) The tips bend over and are taped.
 - e) An alternative is to twist the ends together and use a solderless connector (wire nut), twisting it on the ends of the wire.
 - 5) The spring-loaded connector
 - a) Inside its insulating shell there is a cone-shaped metal spring.
 - b) Screw the connector over the wires to be joined.
 - c) The insulating cover provides a good grip.
 - d) In screwing it on, the cord spring temporarily unwraps, but when released forms a very tight grip on the wire.
 - 6) For wires too large to be joined by the methods described earlier, heavy duty connectors made of copper and tightened with bolts or U-bolts are used. They must be taped.
 - 7) If splicing two conductor wires make sure you do not splice the wrong wires together, and be sure to insulate the two wires from each other before taping the whole wire. Having the wrong wire in contact with each other will cause a short circuit.
4. Almost all farm buildings require lighting whether it is for animals, i.e., chickens, or for people to be able to find something at night. This section will cover wiring lights and switches. Use evaluations as guides.

How do you wire a light circuit?

- 1) Tools needed:
 - a) Standard screwdriver
 - b) Lineman's pliers
 - c) Needle-nose pliers
 - d) Wire strippers
- 2) Hardware needed:
 - a) Nonmetallic lighting outlet
 - b) Octagonal box (nonmetallic or corrosion resistant)
 - c) Single-pole toggle switch
 - d) Mounting box for switch (same characteristics as 2)
 - e) Length of number 12 wire NMC, UF
- 3) If the power wire from the service entrance runs to the light before the switch, feed the power wire through a knock-out on one side of the octagonal box and attach the neutral wire (white) to the silver screw on the light outlet. Splice the black wire to the black wire that runs to the switch.

F. Summary

There are basic rules to follow when wiring an electrical circuit and basic tools that are used in the procedure. The keys are to use the proper tools, do neat work, and follow the procedures carefully and accurately.

G. Evaluation

Answers to Exam

1. Complete the wiring examples provided as handouts to test skills in electrical wiring.

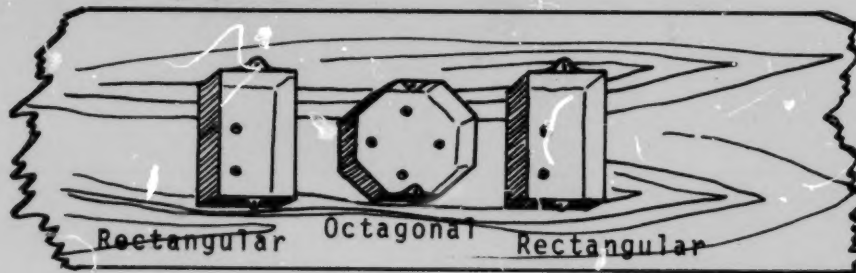
PRACTICAL EXERCISE

Wiring Switches and Receptacles

PROCEDURE

(NOTE: Safety glasses should be worn at all times.)

1. Attach boxes to plywood.



2. Measure cable and cut to proper length.

(NOTE: On each end leave approximately 8" of cable sticking through the boxes.)

3. Remove plugs from each box so cable can be installed.

4. Loosen screw in boxes on holddowns and install cables.

5. Tighten screws and holddowns.

6. Remove 6" of outer insulation from the cable using the stripper or knife.

(NOTE: Be careful not to cut your hand when using a knife.)

7. Remove 1/2" to 3/4" of insulation from the end of each wire.

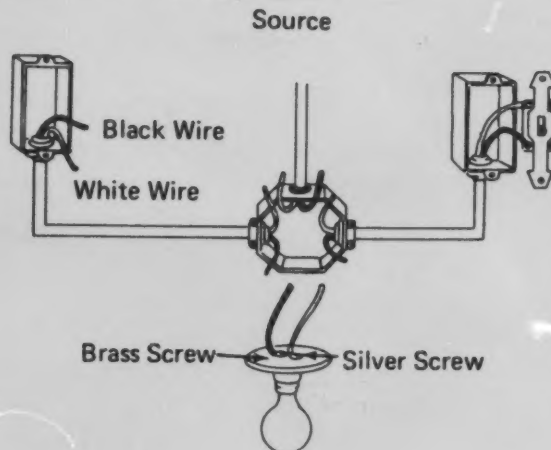
(CAUTION: Do not scratch or nick the wire when removing insulation.)

8. Connect single-pole switch to wire.

(NOTE: Connect the white wire to the brass screw and black wire to the silver screw. This is the only time a white wire will be connected to the brass screw and black wire connected to the silver screw. The black wire is referred to as the traveler wire on the switch leg.)

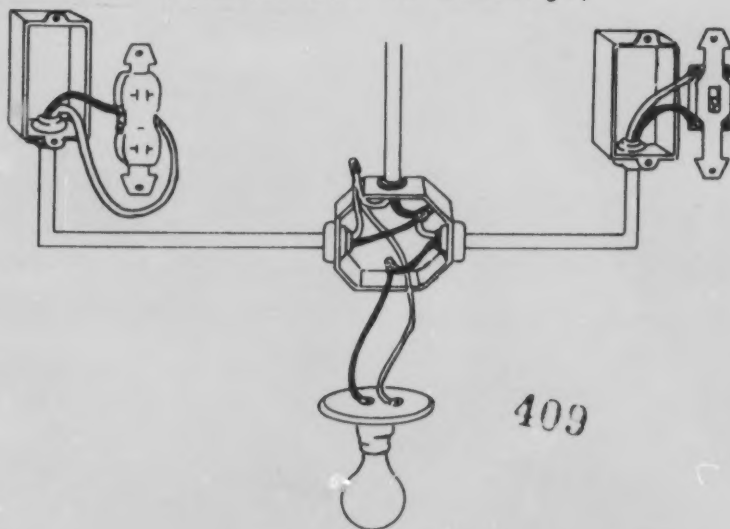
9. Place wires on terminals.

10. Connect the black wire to brass screw in lighting outlet.
11. Connect the white wire from switch to black wire from source.



12. Install duplex receptacle..
13. Connect black wire to brass screw on receptacle.
14. Connect the white wire to silver screw on receptacle.
15. Connect the black wire from the receptacle to the connection of black wire from the source in the octagonal box with a solderless connector.
16. Cut a short pigtail wire (white) and connect to silver screw on lighting outlet.
17. Connect white wire from source, white wire from receptacle, and white pigtail from lighting outlet with a solderless connector inside the octagon box.

(NOTE: Make sure no bare wire is showing.)



409

PRACTICAL EVALUATION
Part 2
Wiring Three Duplex Receptacles Using Nonmetallic Cable

PROCEDURE

(NOTE: Safety glasses should be worn at all times.)

1. Secure boxes for receptacles to demonstration board. You will need 3 rectangular boxes.
2. Remove knock-out plugs on boxes A and B on both ends but remove only one knock-out on box C.
3. Loosen screw inside all three boxes.
4. Start with box C and place wire 1 under screw plate, allowing six inches to extend from box; tighten screw.

(CAUTION: Tighten screw firmly but do not cut insulation.)

5. Place remaining end of wire 1 under screw plate of box B, allowing six inches to extend from the box; tighten screw.
6. Place wire 2 in box B under screw plate of box, allowing six inches to extend from the box; tighten screw.
7. Place the remaining end of wire 2 in box A under screw plate of box, allowing six inches to extend from box; tighten screw.
8. Place wire 1 under screw plate of box A, allowing six inches to extend from the box.
9. Remove approximately five inches of the outside insulation on each wire extending from switch box.

(NOTE: Remember to use caution in removing insulation.)

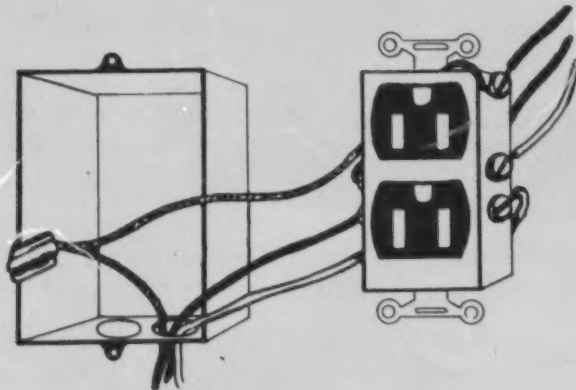
10. Remove approximately 1/2" to 3/4" of insulation from each wire extending from switch boxes.

(NOTE: Remember to use caution in removing insulation from wires.)

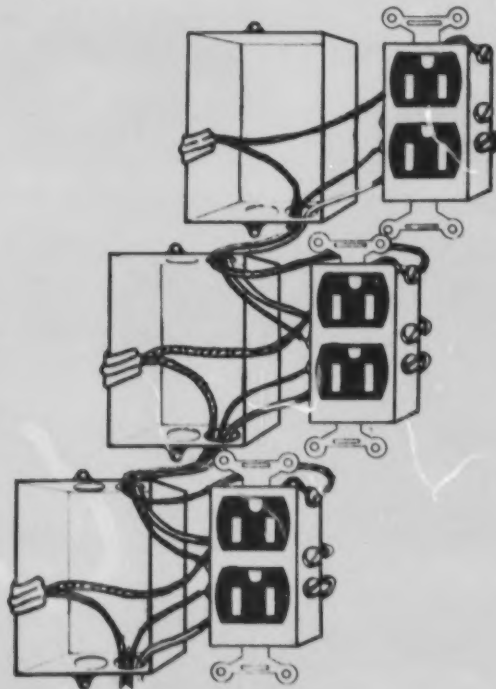
11. Start with box C and attach black hot wire to brass side of receptacle.

(NOTE: Wire should be placed around terminals according to the direction the screw tightens.)

12. Attach white neutral wire to silver side of receptacle.
(See Diagram.)
13. Attach bare ground wire to the top of receptacle.



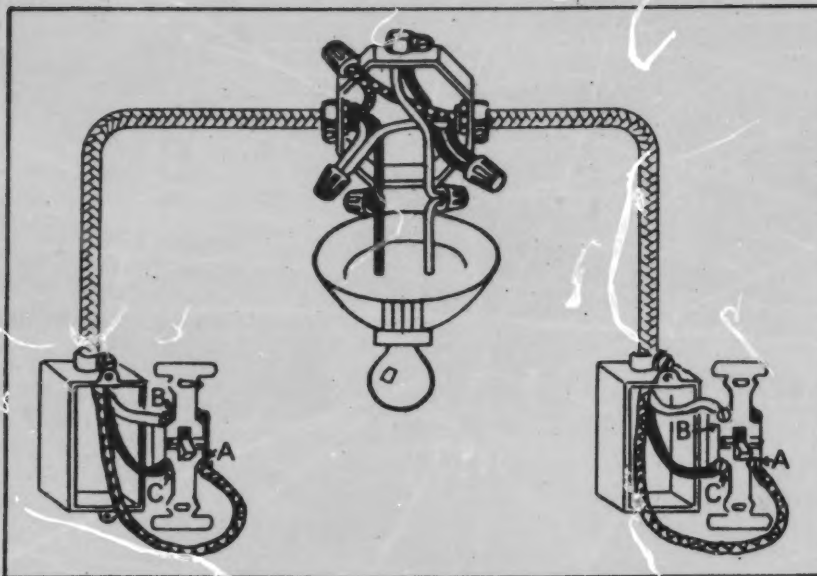
14. Follow same procedure for attaching wires to receptacles A and B.
15. Assemble wires with receptacle and place in box; attach cover plate.
16. Check with instructor for approval before attaching wire 3 to electrical source.



PRACTICAL EVALUATION
Part 3
Wiring a Lighting Outlet Controlled by
Two or Three-Way Switches

PROCEDURE

1. Attach octagonal box and two switch boxes to wiring board.
2. Remove approximately six inches of the outside insulation on each end of the NM cable.
3. Remove knock-out plug from switch box and loosen screw in box; place one 12/3 NM cable under plate and allow approximately eight inches to extend from box; tighten screw.
(CAUTION: Be careful not to tighten screw too tightly because it will cut the insulation on the wire.)
4. Remove 1/2" to 3/4" of insulation from wire.
5. Remove knock-out plugs on octagonal box located directly across from each other.
6. Use the remainder of wire extending from switch box and run to octagonal box; use same procedure for fastening wire to octagonal box as in fastening to switch box.
7. Repeat the same procedure with other 12/3 NM cable, connecting the other switch box to the octagonal box.
(NOTE: While conducting this step, you will need to repeat steps 3, 4, and 6.)
8. Remove six inches of outside insulation from both ends of the 12/3 NM cable.
9. Knock out one of the remaining plugs in the octagonal box.
10. Pull eight inches of the cable through the box and secure to clamp; remove 1/2" to 3/4" of insulation from each wire.
(CAUTION: This should be done in such a manner as to not scratch or mark the wire.)
(NOTE: The other end of this cable extending from octagonal box will be connected to source at completion of job.)
11. Connect black wire to three-way switch on screw C in switch box 1; connect red wire to screw A and white wire with tracer to screw B. (See diagram on next page.)



12. Connect black wire to the other three-way switch on screw C in switch box 2, the red wire to screw A, and the white wire with tracer to screw B.

(NOTE: Wire should be placed around terminals on switch according to the way the screw turns.)

13. Connect the two red wires in the octagonal box together using a pigtail splice.
14. Connect the two white wires with tracers in the octagonal box using a pigtail splice and connecting cap.
15. Connect the black wire from the source to the black wire going to switch 1 using a pigtail splice.
16. Connect the black wire from switch 2 to the brass screw on the light fixture.
17. Connect the white wire from source to the silver screw on the light fixture.

(CAUTION: Check with instructor before performing the next three steps.)

18. Place wires in switch boxes and fasten switches to the boxes; install switch cover plates.
19. Place wires in octagonal box and fasten light fixture to box.

(CAUTION: Do not overtighten fixture.)

20. Connect wire extending from octagonal box to source.
21. Turn switches off and on to see if job is correct.

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 13 - How is electrical power and cost calculated on the farm?

Objective: By the conclusion of the lesson, the student will be able to calculate electric power utilizing Ohm's Law, and calculate cost.

Study Questions:

1. What is the power equation, Ohm's Law and their application?
2. How is electricity measured on the farm?
3. How is the cost of electricity determined for each plan?

References:

1. Wiring Simplified, H.P. Richter, Park Publications Inc., 1999 Shepard Road, St. Paul, MN 55116. Available through IML, UNC.

Transparencies:

1. TM #1: Formulas
2. TM #2: Meter Reading

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 13 - How is electric power and cost calculated on the farm?

TEACHING PROCEDURE

- A. Review terminology and basic electron theory.
- B. Motivation - How is electric cost determined? Who in the class can read an electric meter? Bring a meter into class and have several students read it; check their results.
- C. Assignment - Read the meter at each student's home daily; calculate use and cost.
- D. Supervised Study - Brainstorm on the major uses of electricity around the farm. Discuss ways to curb electric costs.
- E. Discussion

1. In the calculation of electric power four factors emerge: Watts, Volts, Amperes, and Resistance. To determine any of the above a knowledge of Ohm's Law is important. See TM #1.

What is the power equation, Ohm's Law and their applications?

- 1) Power (watts) = Current (amps) x Voltage (volts)
 - a) Current = Watts/Volts
 - b) Voltage = Watts/Current
- 2) Ohm's Law
 - a) Current (amps) = Volts/Ohm's (resistance)
 - b) Ohm's = Volts/Current
 - c) Voltage = Current x Ohm's
- 3) Voltage varies the least, usually 120 or 240 volts in farm circuits.
- 4) Example
 - a) 120-volt circuit
 - b) Five 100 watt lights
 - c) 1/4-hp motor (1-hp = 1000 watts)
 - d) Watts = $(5 \times 100) + (1000/4) = 750$ watts
 - e) Amps = Watts/Volts, $750/120 = 6.25$ -amps
- 5) Meters are available for each part.
 - a) Ammeter - amperage
 - b) Volt meter
 - c) Watt meter
 - d) Ohmmeter
- 6) Ammeter measures flow so must be in the line. (hot)
- 7) Volt meter measures pressure so it is connected across black and white wires.
- 8) Watt meter does both. (Remember $W = A \times V$.)

- 9) Ohm's Law determines the resistance to the flow.
2. To calculate the electrical usage on the farm, you must be able to read and understand the measurements used to check consumption.

How is electricity measured on the farm?

- 1) Power is measured in watts or kilowatts. (1000 watts)
 - 2) Power is calculated by voltage x amperage.
 - 3) The unit used to measure flow is a watt meter or commonly called the Electric Meter.
 - 4) On a dial type meter consumption is read from left to right.
 - a) First dial is read counterclockwise.
 - b) Second dial is read clockwise.
 - c) Third dial is read counterclockwise.
 - d) Fourth dial is read clockwise.
 - 5) If pointer lies between numbers, read the smaller one. See TM #2.
3. Electric bills are calculated monthly in some areas and every other month in others. The bill is based on several scales with electricity becoming "cheaper" with increased usage.

How is the cost of electricity determined for each farm?

- 1) To calculate a bill you need:
 - a) A rate scale
 - b) Total kilowatts consumed
- 2) Example
 - a) First meter reading 0 kwh
 - b) Second meter reading 550 kwh
 - c) Third meter reading 2061 kwh
 - d) Rate scale
 - i) \$.05 first 100 kwh
 - ii) \$.04 next 200 kwh
 - iii) \$.03 next 300 kwh
 - iv) \$.02 next 500 kwh
 - v) \$.01 over 1100 kwh
 - e) Subtract a) from b) $550 - 0 = 550$ kwh
 - i) First 100 kwh x .05 = \$5.00
 - ii) Next 200 kwh x .04 = \$8.00
 - iii) Next 250 kwh x .03 = \$7.50
 - iv) Bill for first time period \$20.50.
 - f) Subtract b) from c) $2061 - 550 = 1511$ kwh
 - i) First 100 kwh + \$5.00
 - ii) Next 200 kwh + \$8.00
 - iii) Next 300 kwh = \$9.00
 - iv) Next 500 kwh x .02 = \$10.00
 - v) Remaining 411 kwh x .01 = \$4.11
 - vi) Bill for second time period = \$36.11

F. Summary

Ohm's Law of Amps x Volts = Watts gives us a way to measure the flow of electricity through the farm system. It lets the farmer calculate loads for each building, check costs, and helps to plan for expansion of the electrical system.

G. Evaluation

Answers to Exam

1. a. 1) .91 Amps
2) .73 Amps
- b. 1) 88.33 Volts
2) 1.33 Volts
- c. 1) 720 Watts
2) 4800 Watts
2. \$45.49

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 13 - How is electrical power and cost calculated on the farm?

EXAM

1. Calculate these values.

a. Find the amperes

- 1) Volts 110 Watts 100
- 2) Volts 240 Watts 175

b. Find the volts

- 1) Watts 500 Amps 6
- 2) Watts 12 Amps 9

c. Find the watts

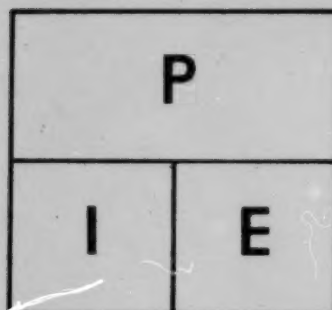
- 1) Volts 120 Amps 6
- 2) Volts 240 Amps 20

2. Calculate the cost of electricity.

a. Meter readings 0123 first, 2222 second.

Costs	.055 first 100 kwh
	.045 next 200 kwh
	.035 next 500 kwh
	.025 next 700 kwh
	.01 over 1500 kwh

Formulas

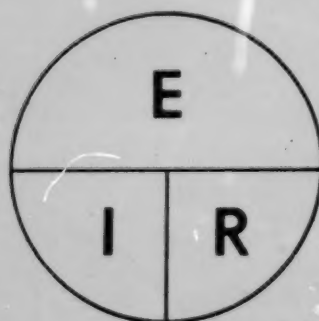


P = Watts

I = Amperage

E = Voltage

Note: Cover the letter you wish to find to discover the method.



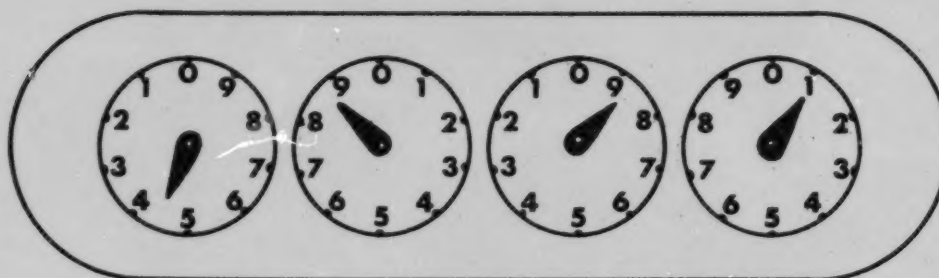
E = Voltage

I = Amperage

R = Ohms

Note: Cover the letter you wish to find to discover the method.

Meter Reading



July 15

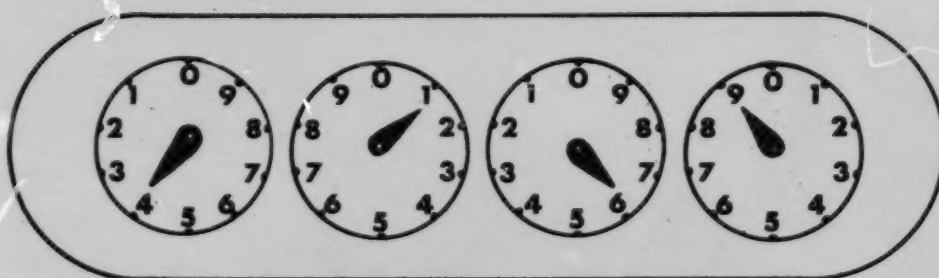
Right dial closest number ---1

Next dial-number passed --8-

Next dial-number passed -9--

Next dial-number passed 4---

Reading = 4981 kwh



June 16

Right dial closest number ---9

Next dial-number passed --6-

Next dial-number passed -1--

Next dial-number passed 4---

Reading = 4169 kwh

Answer $4981 - 4169 = 812$ kwh

UNIT - ELECTRICAL WORK ON THE FARM

Lesson 14 - Protecting the Farmstead from Lightning

Objective: By the conclusion of the lesson, the student will be able to plan and install lightning protection for his/her farm.

Study Questions:

1. What is lightning and why does it strike structures?
2. What lightning protection is necessary for the farm?
3. What constitutes a good system of protection?
4. How is the lightning protection system installed on the farm?
5. How is equipment protected from lightning?
6. How is lightning grounded off a structure?

References:

1. "Electrical Grounding for Personal and Equipment Safety." MU Guide #1022.
2. "Installing Lightning Arresters for Equipment Protection." MU Guide #1021.
3. "Lightning Protection for Missouri Farms and Homes." MU Guide #1020.

Transparencies:

1. TM #1: How Lightning Strikes
2. TM #2: Lightning Protection Devices
3. TM #3: Recommended Grounding Practices for Buildings
4. TM #4: Recommended Grounding Practices for Waterers

Handout:

1. HO #1: Recommended Grounding Practices

NIT - ELECTRICAL WORK ON THE FARM

Lesson 14 - Protecting the Farmstead from Lightning

TEACHING PROCEDURE

- A. Review basic electricity especially the flow of electrons and proper grounding.
- B. Motivation - Use a battery to show the jumping of electric charges from negative to positive. Use a capacitor to increase the voltage for a longer jump. This will demonstrate the jumping of a charge from a cloud of negative charge to the earth with a positive charge.
- C. Assignment - Do an electrical grounding check of each student's homestead checking for lightning arresters, lightning rods, and fence grounding.
- D. Supervised Study - As a group evaluate the protection of a theoretical farm to plan for maximum protection. Look for the flaws.
- E. Discussion
 1. Charges from the sky (lightning) kill 400 people a year and cause millions of dollars worth of damage to property and livestock a year. Thirty-seven percent of fires started last year were attributed to lightning.

What is lightning and why does it strike structures?

- 1) In Missouri
 - a) Average of 61 thunderstorm days a year
 - b) Lightning occurs 1 out of 6 days.
- 2) Lightning
 - a) Uncontrollable giant electric spark
 - b) Follows shortest, easiest path to earth
 - c) Because of great power may follow several paths
 - d) Caused by static charges jumping from negative charge to positive charge over an air gap. See TM #1.
 - e) Positive charges build in protecting objects.
2. Lightning protection for the farm involves more than protecting from loss of life. Protection is needed from fire and electrical surge damage.

What lightning protection is necessary for the farm?

- 1) These factors determine the size of the system.
 - a) Frequency and severity of storms
 - b) Value and nature of each building
 - c) Relative building exposure
 - d) Hazards to people
 - e) Insurance on the farm
 - 2) Lightning can reach farther than the point of impact.
 - 3) Livestock protection
 - a) Ground wire fences with 1/2-inch copper or 3/4-inch galvanized pipe, 10 feet deep at 150-foot intervals
 - b) Ground tall objects. They will provide a cone of protection two times the height of the object where system is mounted, making a circle of protection.
 - 4) Rules for people
 - a) Do not go or stay outdoors during a storm.
 - b) Seek shelter in a protected building.
 - c) Avoid tents, etc.
 - d) Avoid open areas, water, isolated objects.
 - e) Seek dense woods, low areas, buildings in low areas.
3. Proper planning before installing will insure a protection system worthy of praise. Safeguarding your facilities and livestock is important.

What constitutes a good system of protection?

- 1) Provide a means by which a discharge may enter or leave the earth without passing through a structure or object.
 - 2) For proper protection of a building See TM #2.
 - a) Properly sized, placed and installed air terminals to receive the lightning stroke
 - b) Down conductors designed to carry discharge to ground
 - c) Ground rods of adequate size, properly located, driven into moist earth
 - d) Interconnecting conductors of proper size and type
 - 3) Materials need to be resistant to corrosion.
 - a) Copper
 - b) Aluminum
 - 4) Because aluminum will corrode in contact with earth, use copper conductors and bimetal connectors. Look for the UL label.
4. Without proper installation the system will be worthless or offer only minimal protection. The following guidelines for installation should be followed during installation.

How is the lightning protection system installed on the farm?

- 1) The installation of lightning protection system is as important as the materials used. A few considerations will help you decide whether you shall have a complete system:
 - a) A sufficient number of air terminals or points must be spaced properly.
 - b) Turns should not exceed 90 degrees and no bend should have less than an eight inch radius.
 - c) Entrance conduits, gutters, drain pipes, pipe vents, metal water pipe, radio and T.V. antennas, metal roofing, fences and other metal objects should be bonded to main down conductors and ground rods. The bonding conductor must be at least Number 6 A.W.G. copper or equivalent.
 - d) Lightning system ground rods (electrodes) must be driven to a minimum depth of 10 feet-- where soil conditions permit. When rocky terrain prohibits this, alternate grounding procedures, as discussed below, must be used. Use no less than two rods for major buildings, one at opposite corners of each building. Locate ground rods two feet from the building foundation and drive rod well under the surface of the ground.
 - e) Buildings with a perimeter of over 250 feet need one additional down conductor for each additional 100 feet.
 - f) Water towers, silos, metallic spires, flag poles, tall trees, etc. should have their individual protection systems.
 - g) If driven grounds used for the electrical and/or the telephone systems are within 6 feet of a lightning protection system ground, all must be bonded together to prevent side flashes.
 - h) Protect down conductors from mechanical damage by enclosing in a conduit or metal tubing. Extend conduit from a point at least five feet above ground level to one foot below ground surface.
5. Equipment protection is as much a concern as protecting the farmstead or family from lightning. An overload on the electrical system can destroy electric motors and cause fires in this equipment.

How is equipment protected from lightning?

- 1) Lightning arresters are usually one of two types, the capsulated pellet type or the air gap type.
 - a) Each must remove the high voltage charge and conduct it harmlessly to the ground.
 - b) Interrupt the flow of the normal power current which would try to follow this high voltage discharge path.
 - 2) The pellet-type arrester is made up of a tube containing a column of small lead peroxide pellets that are coated with an insulating film.
 - 3) A sealed dry air gap, in series with the path formed by the pellets, is designed to spark over at least a constant voltage value. Its high resistance at circuit voltage and low resistance at high voltage allows these arresters to function many, many times without internal damage.
 - 4) Each acts like a safety valve, automatically draining the high voltage lightning surges into the ground.
 - 5) Most home lightning arresters are smaller than a baseball and are designed for single-phase 120/240 volt, three-wire service with grounded neutral.
 - 6) Properly installed, they provide a lightning discharge from electric lines to earth, allowing the surge to bypass home wiring and equipment.
 - 7) The effectiveness of the arrester is dependent upon how well the home or farm wiring system is grounded.
 - 8) Lightning arresters should be installed at the point where electrical service wires enter each major building.
 - a) The connecting wires between the arrester and the three service conductors are as short as possible with installation made near the service entrance weatherhead.
 - b) Lightning arresters should also be installed ahead of specialized electrical loads like submersible water pumps, high feed handling or other equipment that might be located away from, or outside of, arrester protected buildings.
 - c) When such remotely located equipment is served with underground electrical cables, the arrester can be placed on the fuse box or service entrance box. Refer to HO #1.
6. The grounding procedures for a farm structure will determine the extent of protection available. In this section, electrical grounding systems will be explained.

How is lightning grounded off the structure?

- 1) Electrical grounding consists of connecting one end of a properly sized copper conductor to the metal part of equipment and the other end to a metal conductor that is in direct and permanent contact with earth.
- 2) The National Electrical Code states that in metallic water system a minimum of three feet deep and ten feet long which is in direct contact with earth must be used as a ground.
- 3) Where a water system is not available then a 1/2-inch diameter copper rod, a 5/8-inch copper-clad rod or a 3/4-inch trade-size galvanized iron pipe should be driven a minimum of 8 feet into the earth.
- 4) If the soil is rocky a 10-foot-long electrode can be laid in a three- or four-foot deep trench.
- 5) The size of the ground wire to connect to the grounding electrode is determined by the service entrance wire size.

Service Entrance
Wire Size

up to #2 AWG
#1 or #0 AWG
#00 or #000 AWG
#0000 or #350 MCM

Copper Ground
Wire

#8 AWG
#6 AWG
#4 AWG
#2 AWG

- 6) Carefully clamp the wire to the grounding electrode using lugs or clamps; never use a steel strap or solder.
- 7) If the water line is used as a ground, a grounding jumper should connect around plastic pipe sections, gasketed water meters and hose-connected water softeners.
- 8) Two transparencies are included in this lesson to show recommended grounding practices. See TM #3 and #4.

F. Summary

Every year 400 or more people are killed and millions of dollars worth of property is destroyed by lightning. This problem can be avoided by properly grounding the structures on the farm which in turn provides a safety area beneath it for people and livestock. Protection must be planned for maximum protection and benefit, and installation be completed carefully.

G. Evaluation

Answers to Exam

1. -, +
2. 400, 37
3. 61
4. 2
5. copper
6. inexpensive, easy
7. 8
8. lugs
9. grounding jumper
10. - to +

~~DO NOT WRITE IN THESE SPACES~~

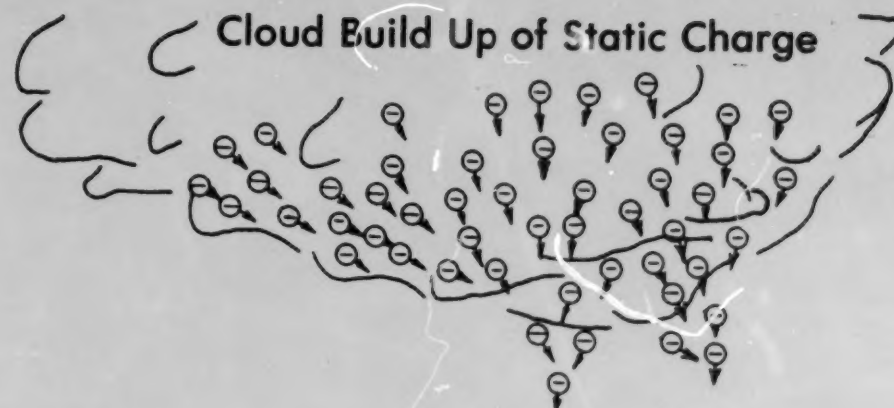
UNIT - ELECTRICAL WORK ON THE FARM

Lesson 14 - Protecting the Farmstead from Lightning

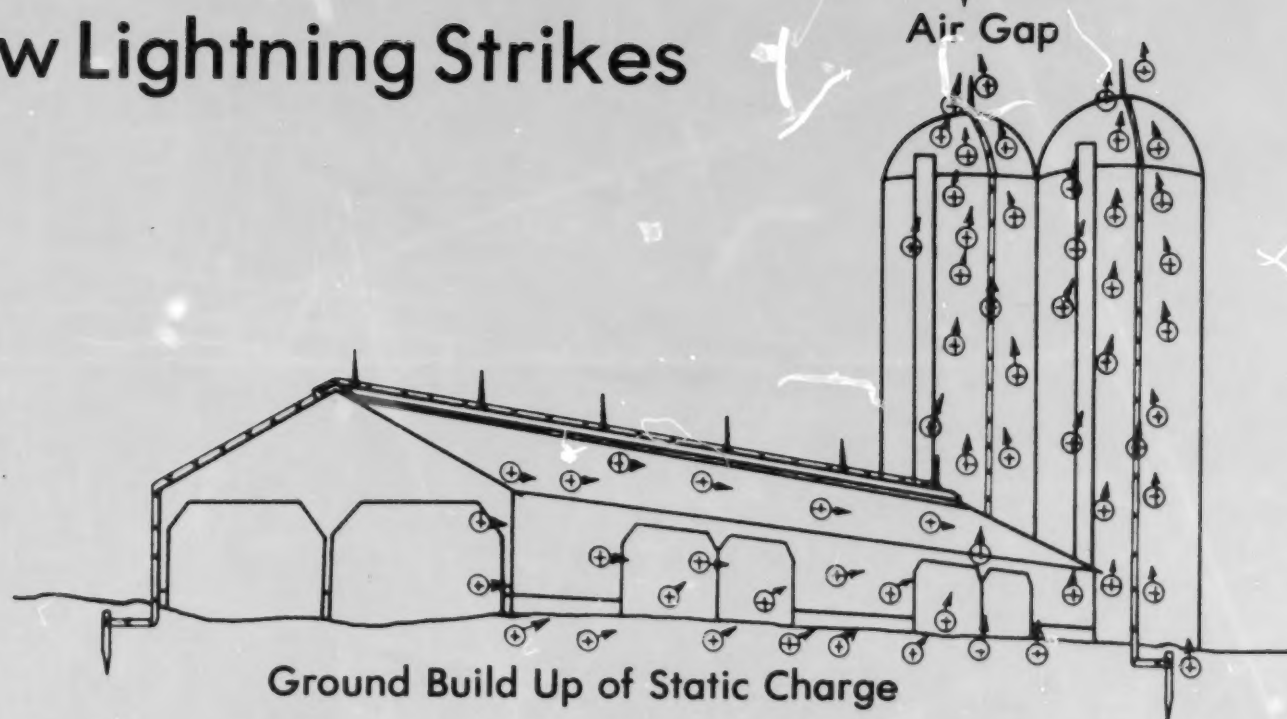
EXAM

Directions: Circle the correct answer in each set of parenthesis.

1. In a thunderstorm the clouds have a (+, -) charge and the earth has a (+, -) charge.
2. Lightning kills (200, 300, 400) people a year and causes (27, 37, 47%) of fires started each year.
3. Missouri has an average of (51, 61, 71) thunderstorms a year.
4. Grounding a tall structure, silo, will expand the protection on the ground about (1, 2, 3) times the height of the structure.
5. The best conductors to use for a grounding rod is (steel, copper, aluminum, galvanized.)
6. A lightning arrester is (expensive, inexpensive and easy, difficult) to install.
7. The grounding rod should be driven (6, 8, 10) feet into the ground.
8. Connecting the ground wire to the grounding rod should be done with (steel straps, lugs, solder.)
9. To protect a water meter from an electrical overload install a (separate ground, grounding jumper, or lightning rod.)
10. The electric spark jumps from (+ to -, - to +, + to +, - to -.)



How Lightning Strikes

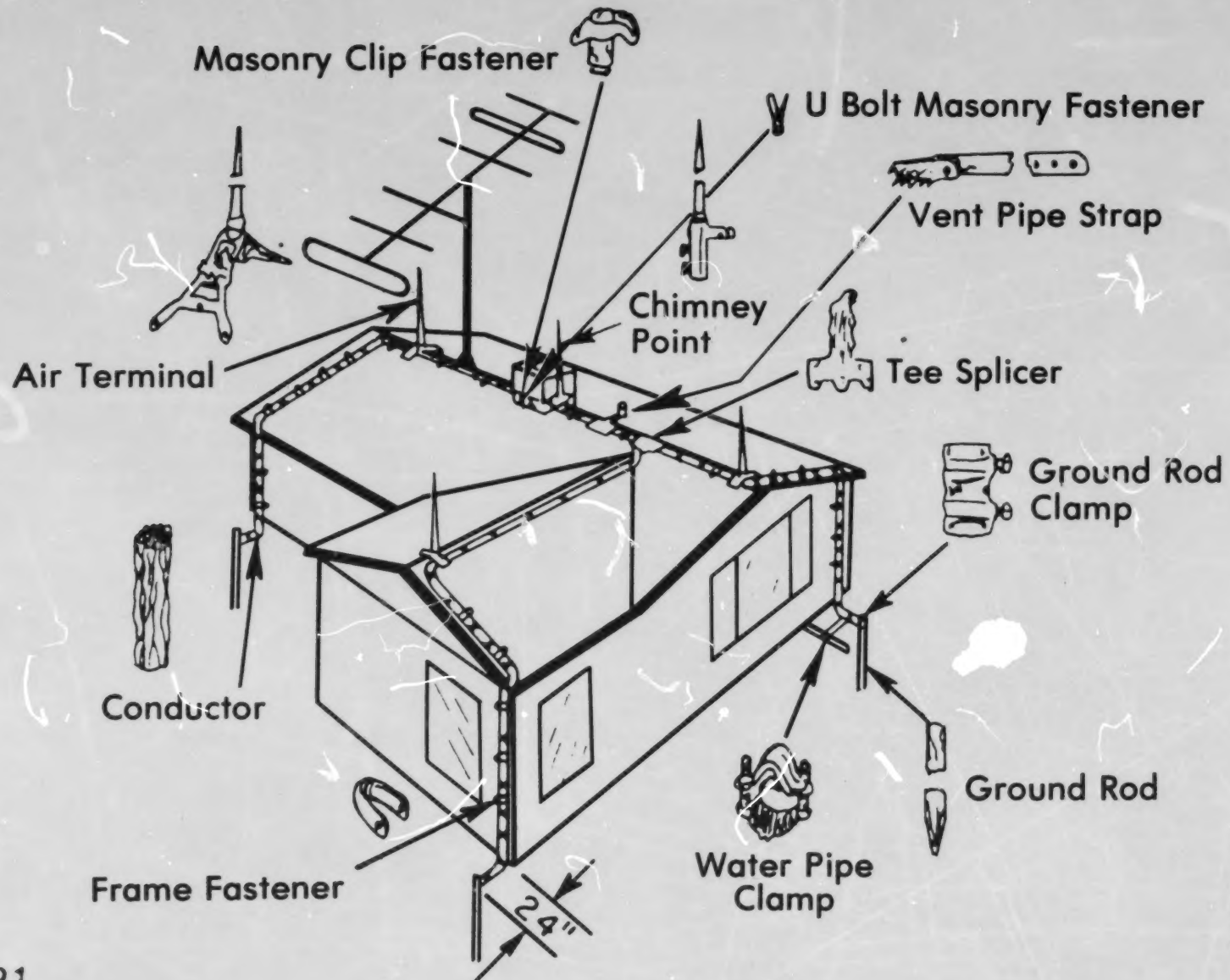


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When force is great enough to puncture air gap insulator charge follows path of least resistance, to ground.

TM-130
430

Lightning Protection Devices



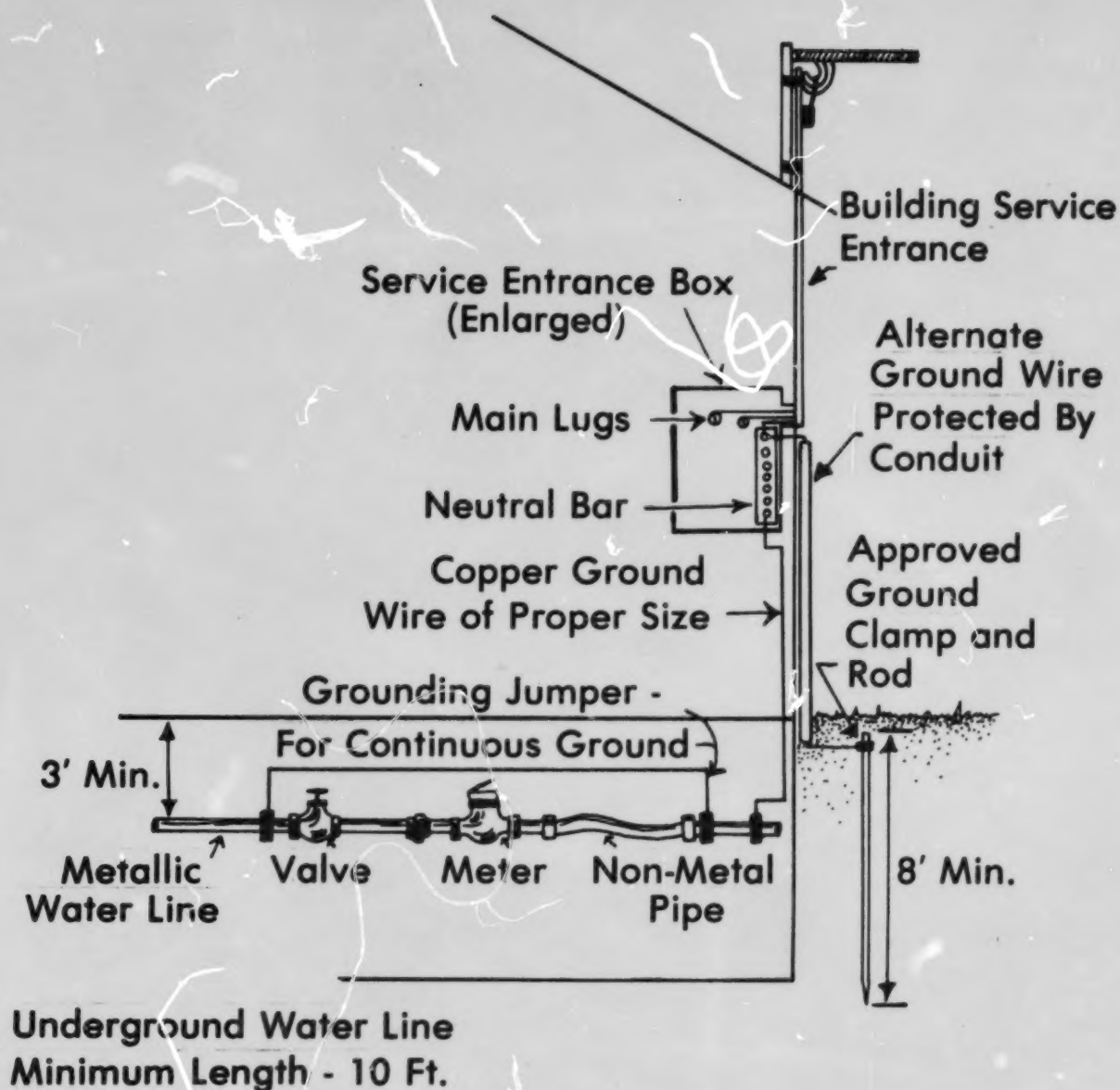
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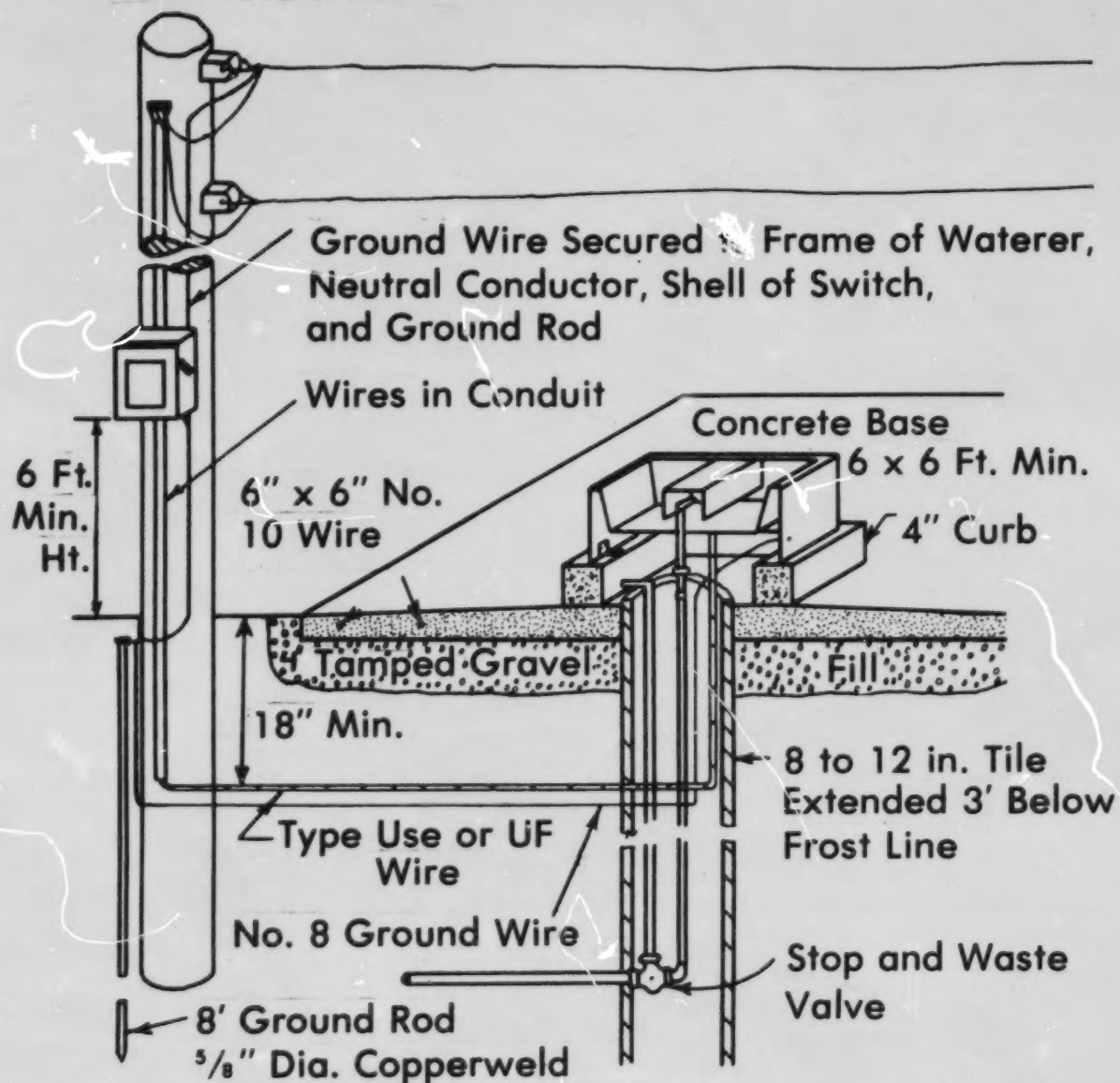
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Recommended Grounding Practices for Buildings

TM-3



Recommended Grounding Practices For Waterers



RECOMMENDED GROUNDING PRACTICES

Section 250-131. Secondary Services, 750 Volts or Less. Where a lightning arrester is installed on a secondary service, the connections to the service conductors and to grounding conductor shall be as short as practicable. The grounding conductor may be (1) the grounded service conductor, or (2) the common grounding conductor, or (3) the service equipment grounding conductor. The bonding or grounding conductor shall be of copper not smaller than Number 14 or of equivalent corrosion-resistant material.

Section 280-23. Connections - Size and Material The connections between the arrester and the line wire or bus, and between arrester and ground shall be of copper wire or cable or the equivalent, and, except as provided on secondary services in Section 250-131, shall not be smaller than Number 6, and shall be made as short and as straight as practicable, avoiding as far as possible all bends and turns, especially sharp bends.

The National Electrical Code section 280-23 suggests the use of Number 6 *Copper* wire. If these copper conductors are to be attached to aluminum conductors, a special coated connector must be used. This special connector, designed for bonding together two dissimilar metals, will retard electrolytic action.

UNIT - PLUMBING ON THE FARM

Lesson 1 - What safety practices need to be followed when installing or expanding plumbing systems?

Objective: At the conclusion of the lesson, students will be able to complete with 100% accuracy a comprehensive test on plumbing safety.

Study Questions:

1. What are the different hazard areas of plumbing?
2. What preventive steps can you take to insure your safety?

References:

1. Mechanics in Agriculture, Lloyd J. Phipps. The Interstate Printers and Publishers, Danville, Ill.
2. Modern Agricultural Mechanics, T.J. Wakeman. The Interstate Printers and Publishers, Danville, Ill.

UNIT - PLUMBING ON THE FARM

Lesson 1 - What safety practices need to be followed when installing or expanding plumbing systems?

TEACHING PROCEDURE

- A. Review the basic safety rules of the shop.
- B. Motivation - Drop a pipe wrench or show the conductivity of metal pipe by heating a section of copper pipe on one end and igniting a piece of paper on the other end.
- C. Assignment
- D. Supervised Study - Discuss the safety hazards in plumbing. Have examples of tools and pipe in the classroom to stimulate discussion.
- E. Discussion
 1. Ask the students to list and discuss the major hazards of plumbing. After listing, devise a set of rules for plumbing safety in the shop.

What are the different hazard areas of plumbing?

- 1) Electrical hazards are of primary concern when installing plumbing. Copper and galvanized pipe will conduct electricity and care must be taken not to contact pipe with electrical source while working.
- 2) When installing metal pipes in an existing structure care must be taken when working the pipe inside the existing walls. Old wiring within the wall could cause a shock.
- 3) Wear gloves whenever possible to prevent pinches and bruises from tools used to cut or connect pipe.
- 4) Shore up any walls in a trench when installing sewer lines or water lines to prevent cave ins.
- 5) Fire hazards exist with types of plastic pipe because they are petroleum based. Installation near heating elements could cause a serious fire by melting and igniting a plastic pipe.
- 6) Be aware of the water pressure when repairing or replacing pipe.
 - a) Shut off all water into the system before starting repairs.
 - b) Once repairs are completed pressurize and check from a distance the soundness of the repair.

- c) Checking for leaks by increasing pressure is asking for trouble; a weak pipe could rupture and compound the problem at hand.
- 7) Eye protection is important in plumbing for several reasons:
 - a) Protects against steam or hot-water burns
 - b) Solvents used to connect plastic pipe can injure the eye or skin.
 - c) Metal filings from threading pipe can damage the eye.

- 2. List on the board the seven safety practices found below and discuss in detail.

What preventive steps can you take to insure your safety?

- 1) Check the electrical system before starting to be sure the power is off in the area where you are working.
- 2) Wear your safety goggles during all phases of plumbing; protect your eyes.
- 3) A hard hat and safety shoes would be beneficial for protection against blows by heavy tools and materials.
- 4) Protect your hands by wearing a pair of working gloves. Dexterity may decrease but protection from cuts and burns will increase. Keep the gloves clean of metal filings and oils that could get into joints, ruining the seal.
- 5) Before repairing a broken pipe, decrease the water pressure to prevent scalds from hot water or water damage to wood.
- 6) Use the proper tools for the job.
- 7) When using plastic pipe be careful with the heat (melting or catching fire) and the solvents used to connect the pipes (highly toxic and injurious to the skin).

F. Summary

Building a good safety attitude will be reflected in low injuries and a safer working environment for all in the shop. Safety rules can also improve the quality of the work by making the worker more conscious of his/her job.

G. Evaluation

Answers to the exam

433

- 1. T
- 2. F
- 3. F
- 4. T
- 5. T

UNIT - PLUMBING ON THE FARM

Lesson 1 - What safety practices need to be followed when installing or expanding plumbing systems?

EXAM

- T F 1. Turning the electricity off before working on the plumbing is a good safety practice.
- T F 2. Safety glasses are not needed when repairing plumbing.
- T F 3. Leaving the plumbing system pressurized will simplify repairs to the system.
- T F 4. Plastic-pipe solvents are caustic and can burn the skin and eyes.
- T F 5. Wearing gloves while repairing plumbing is a good safety practice.

UNIT - PLUMBING ON THE FARM

Lesson 2 - What equipment and supplies are needed to install or repair an on-farm water system?

Objective: After completion of this lesson, the student will be able to identify the equipment and supplies needed to install or repair on-farm water systems.

Study Questions:

1. What tools are necessary to install a plumbing system?
2. What supplies are needed to facilitate functional plumbing construction?

References:

1. Mechanics in Agriculture, Lloyd J. Phipps. The Interstate Printers and Publishers, Danville, Ill.
2. Modern Agricultural Mechanics, T.J. Wakeman. The Interstate Printers and Publishers, Danville, Ill.
3. Shopwork on the Farm, Mark M. Jones. McGraw-Hill Book Co.

Transparencies:

1. TM #1: Plumbing Tools #1
2. TM #2: Plumbing Tools #2
3. TM #3: Plumbing Tools #3

UNIT - PLUMBING ON THE FARM

Lesson 2 - What equipment and supplies are needed to install or repair an on-farm water system?

TEACHING PROCEDURE

- A. Review Lesson 1 to establish a safe working atmosphere and an appreciation of the tools.
- B. Motivation - Lay out the tools to be discussed and let the students examine them and possibly set up a demonstration to show the leverage of wrenches.
- C. Assignment - Give an oral pretest by laying out the equipment and then have the students attempt to name them.
- D. Supervised Study - Lay out the tools and then have the students describe each in their notes. See Wakeman's text, pg. 421.
- E. Discussion
 1. Have the students complete the assignment. Then explain each piece of equipment individually. See TM #1-3.

What tools are necessary to install a plumbing system?

- 1) Pipe wrenches - Pipe wrenches come in various sizes. The sizes are designated by length, ranging from 6" up to 60". For the average plumbing jobs, the 24" pipe wrench will be the largest size needed. The pipe wrench is used for connecting pipe and round fittings.
- 2) Monkey wrenches - Monkey and adjustable wrenches are used when connecting square, hexagonal fittings to pipe.
- 3) Pipe vises - Pipe vises are used to hold the pipe when cutting, threading and connecting pipe. A vise that will hold all sizes of pipe from 1/8" to about 3" is satisfactory for most jobs.
- 4) Pipe cutters - There are two types of pipe cutters. One type has one cutter wheel and two rollers. It is used when there is enough clearance to revolve the cutters completely around the pipe. The other type has three or four cutter wheels and is used when there is not enough clearance to rotate the cutters around the pipe. A pipe cutter from 1/4" to 2" in size is suitable for most plumbing jobs.

- 5) Pipe reamers - Pipe reamers are available in different sizes, but one size serves for several sizes of pipe as the reamers are tapered. They are used to remove any burrs that may be present on the inside of the pipe, and can be used with either a bit brace or tap wrench.
 - 6) Tap wrenches - Tap wrenches are used as the handle for reamers and for pipe taps.
 - 7) Pipe taps - Pipe taps are used for cutting threads inside holes in metal or pipe fittings. Before a pipe can be used, a tap hole must be drilled in the material. Pipe taps range in size to fit all sizes of pipe from 1/8" to about 4". When tapping heavy material, it will be necessary to ream the hole with a regular taper pipe reamer before tapping. Pipe taps and reamers are turned with a regular tap wrench.
 - 8) Pipe stock - Pipe stocks come in various types, the most common of which is the ratcheting stock. The size of a pipe stock depends on the make of the stock and die set. The stock is used to hold the pipe dies.
 - 9) Pipe dies - Pipe dies come in a large range of sizes and usually come in sets along with the pipe stock. Dies are used to cut threads on the outside of the pipe.
2. List the supplies needed on the board or on an overhead and show examples of each to the class. For added interest, demonstrate the properties of each by example, i.e., solvent on plastic pipe, doped vs. undoped pipe for pressure control.

What supplies are needed to facilitate functional plumbing construction?

- 1) Pipe-joint compound - Pipe-joint compound (commonly called "pipe dope") is applied to the threads to prevent pipes from leaking and rusting. It also helps make disassembling easier.
- 2) Thread-cutting oil - Thread-cutting oil is used to lubricate and to prevent excessive wear on cutting wheels and threading dies and is used to help prevent overheating of pipe and equipment. Lard oil or a mixture of lard oil and lubricating oil should be used for all threading and reaming of wrought iron and steel pipe. This oil can be purchased already mixed.
- 3) Propane torch or other heat source - The torch is used to heat copper tubing with solder when sweating on fittings.

- 4) Tubing cutters - Tubing cutters are small pipe cutters used for cutting copper tubing.
- 5) Flaring tools - Flaring tools are used to flare the end of copper tubing when connecting fittings that require flare tubing.
- 6) Tube clamps - Tube clamps are used to hold the tubing and provide a mold for the flare when copper tubing is being flared.
- 7) Flexible tubing bender - Flexible wire tubes used to bend copper tubing
- 8) Copper tubing brush - A copper wire brush used to mechanically clean the interior of fittings and tubing
- 9) Lead and caulking - Cast iron soil pipe makes a solid, tight seal against moisture and vermin.
- 10) Solder-copper - When attaching copper fittings, a heated joint is easily sealed with a tin-lead solder drawn in by flux.
- 11) Solvent-plastic pipe - For a good plastic-to-plastic bonding, a primer is applied to clean the fittings. Then a full, even coating of solvent cement is applied. Be sure to use solvent recommended for the type of pipe being used.

F. Summary

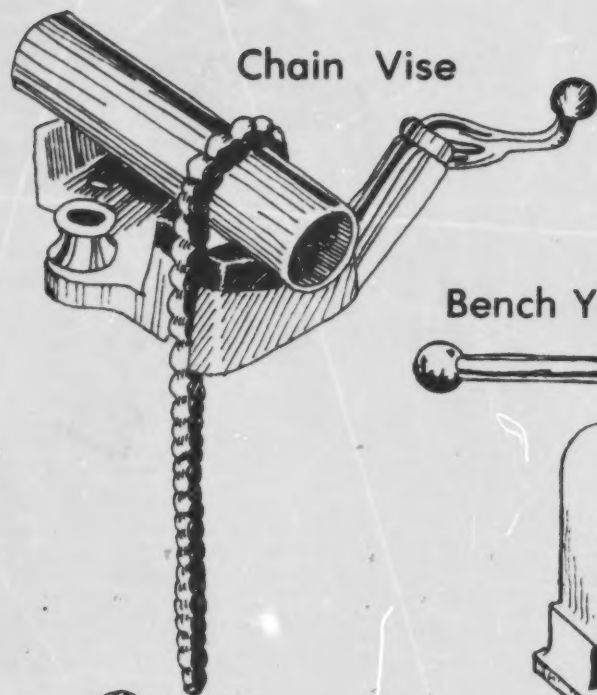
The important tools and supplies needed are:

1. Pipe wrenches
2. Pipe vises
3. Pipe cutters
4. Pipe reamer
5. Pipe stock and die
6. Pipe taps
7. Flaring tools
8. Flexible tubing bender
9. Tubing cutter
10. Pipe-joint compound
11. Lead and caulking
12. Solder
13. Solvent

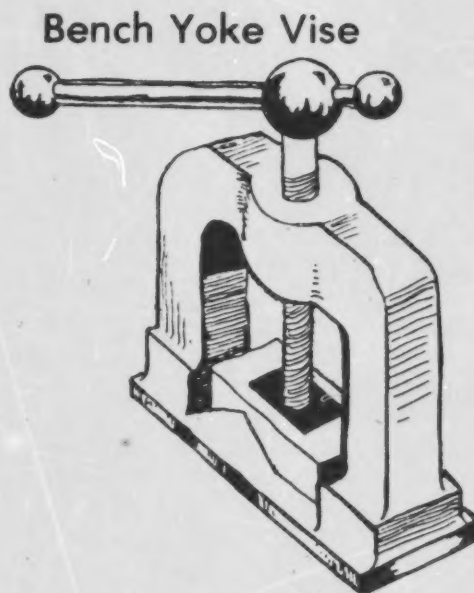
G. Evaluation

Oral quiz to identify the different tools. Transparencies could be used with the names blocked off; preferred would be to set out the tools.

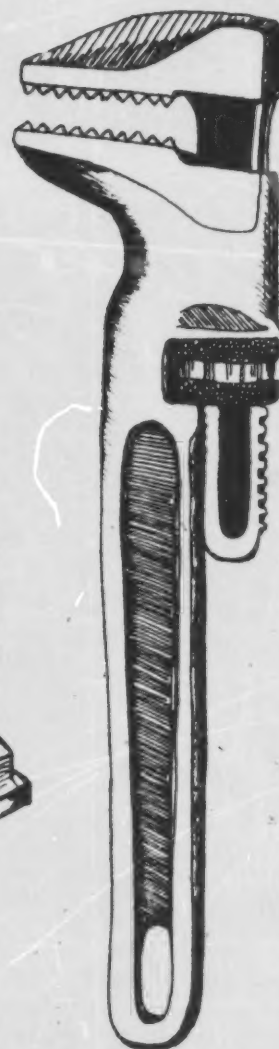
Plumbing Tools



Chain Vise



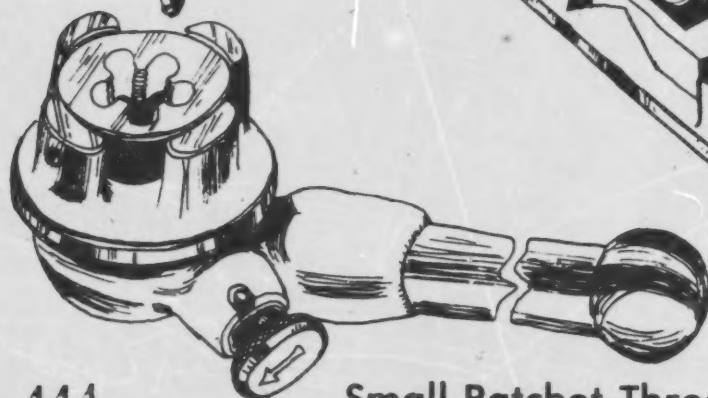
Bench Yoke Vise



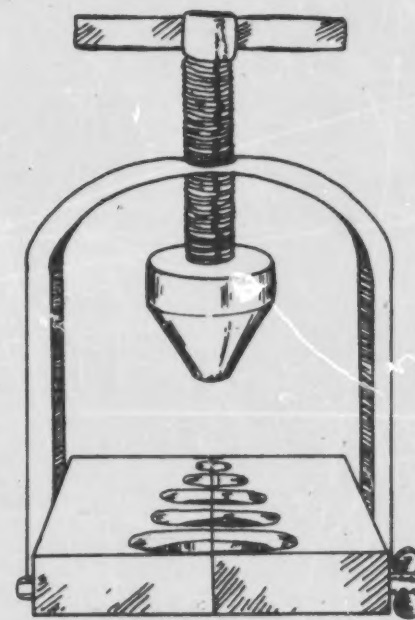
Pipe Wrench



Burr Reamer



Small Ratchet Threader



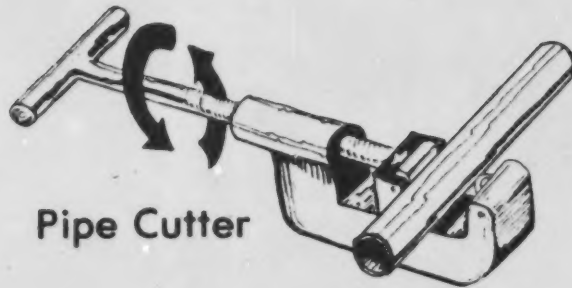
Flaring Tool

444

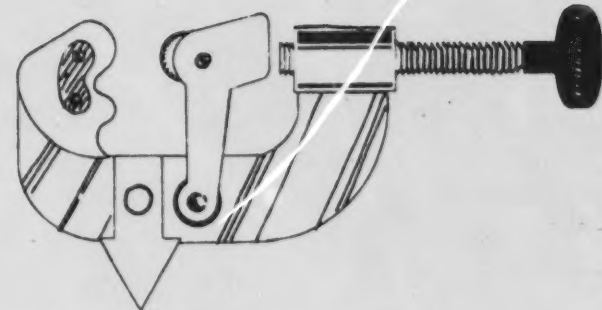
445

TW-1

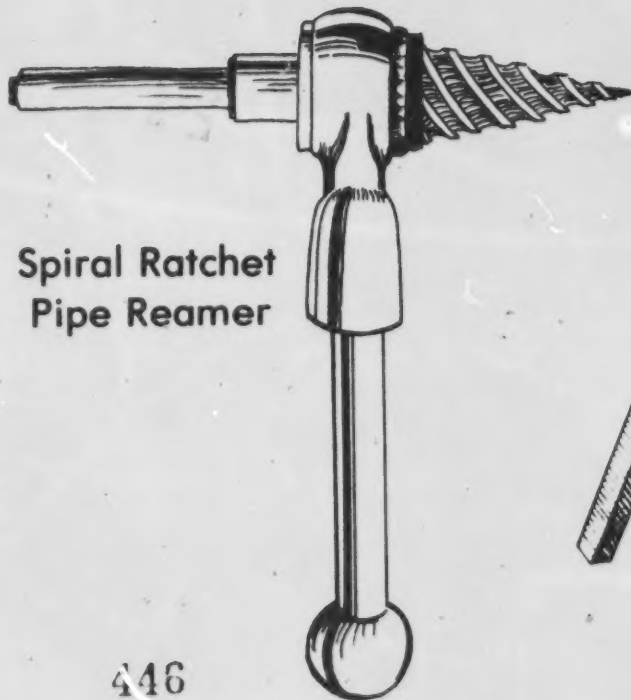
Plumbing Tools



Pipe Cutter



Tubing Cutter



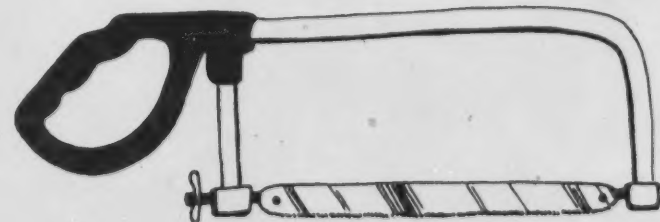
Spiral Ratchet
Pipe Reamer



Tapered
Triangular File



Die



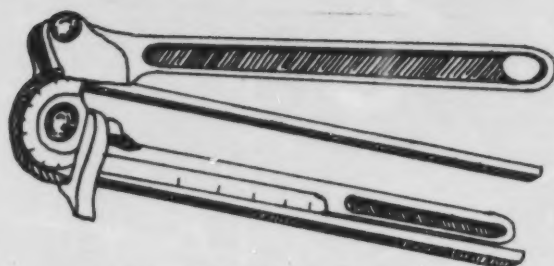
Hacksaw

603

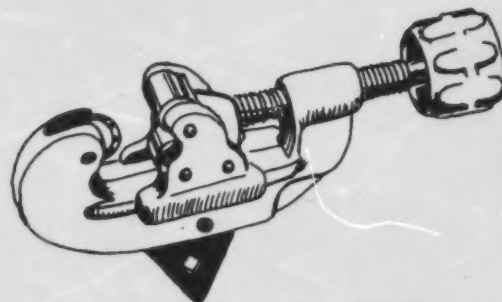
446

447 TM-2

Plumbing Tools



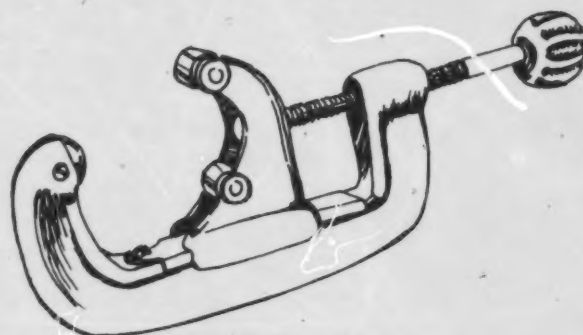
Lever-Type Bender



Small Diameter Cutter



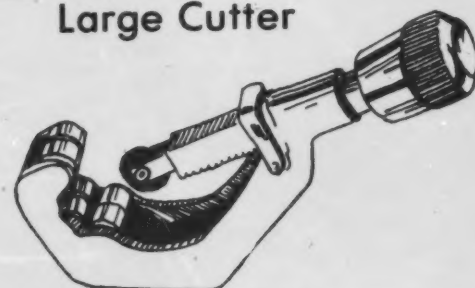
Abrasive Saw



Large Cutter



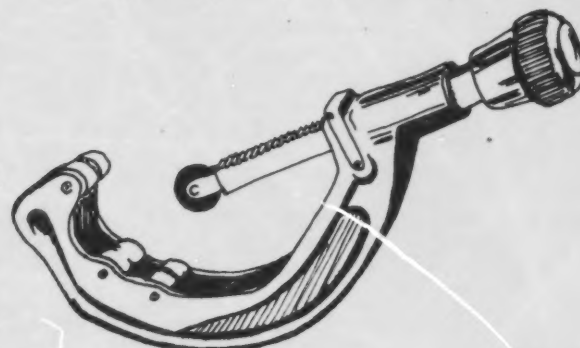
Geared Ratchet-Type Bender



Small Quick-Opening Cutter



Spring Bender



Large Quick-Opening Cutter

UNIT - PLUMBING ON THE FARM

Lesson 3 - What are the types of pipe and fittings used in farm plumbing?

Objective: After completion of this lesson, the student will be knowledgeable in the types of pipe and their characteristics, and the types of fittings used to join pipes.

Study Questions:

1. What are the different types of pipe and what are the characteristics of each?
2. What are the different types of pipe fittings?
3. How do the fittings differ according to the pipe type?

References:

1. Modern Agricultural Mechanics, T.J. Wakeman, The Interstate Printers and Publishers, Danville, Ill.
2. Plumbing-Installation and Design, L.V. Ripka, American Technical Society.
3. Shopwork on the Farm, Jones, McGraw-Hill Book Co.

Transparencies:

1. TM #1: Copper and Plastic Fittings
2. TM #2: Cast-Iron Pipe and Fittings
3. TM #3: Cast-Iron and Steel Fittings
4. TM #4: Expansion and Contraction of Piping

Handout:

1. HO #1: Summary of Comparisons Among Pipe Types
2. HO #2: Plastic Pipe Materials

UNIT - PLUMBING ON THE FARM

Lesson 3 - What are the types of pipe and fittings used in farm plumbing?

TEACHING PROCEDURE

- A. Review units 1 and 2 on safety and tools.
- B. Motivation - Bring in samples of each type of pipe and fittings; compare weights and flexibility.
- C. Assignment - Have the students check their homes and agricultural structures for types of pipe and fittings.
- D. Supervised Study -
 1. Lay out pipe types and have students look for characteristics of each.
 2. Set out the types of fittings and have the students identify them.

E. Discussion

1. Have the students relate plumbing experiences in relation to types of pipe and the uses of each on the farm. Discuss workability, cost, and methods of installment.

What are the different types of pipes and what are the characteristics of each?

- 1) Black pipe
 - a) Used for oil, gas, or air
 - b) In steam and hot-water heating systems
 - c) Uncoated wrought iron or steel pipe; has excellent resistance to force and fires
- 2) Galvanized pipe
 - a) Coated wrought iron or steel pipe outside and inside with a zinc coating
 - b) Highly resistant to corrosion
 - c) Used for hot- and cold-water plumbing
- 3) Cast-iron pipe
 - a) Low carbon, grey cast, nonsteel
 - b) Used for large water mains and sewage lines
 - c) Strong and corrosion resistant
 - d) Will neither leak nor absorb water
 - e) Economical and easily cut or joined
- 4) Copper pipe
 - a) Flexible and/or rigid
 - b) Expensive, but its flexibility makes it easier to work with, especially when updating old facilities because it can be guided through walls easily.

- c) Lightweight
 - d) Easily joined by fluxing or soldering
 - e) Corrosion resistant to water
 - f) Easily corrodible by acids and fumes in sanitary drainage system
 - 5) Thermoplastic pipe See HO #2.
 - a) Four kinds available
 - i) Polyethylene (PE)
 - ii) Polyvinyl Chloride (PVC)
 - iii) Acrylonitrile-Butadiene Styrene (ABS)
 - iv) Chlorinated Polyvinyl Chloride (CPVC)
 - b) PE is flexible while the others are rigid.
 - c) Easier to install and usually cheaper to use than steel or copper
 - d) PE used in new farm watering systems but must be installed out of the reach of animals because it is less durable.
 - 6) Comparison tables
 - a) "Useful Information for the Home, Farm and Ranch"- table comparing the advantages and disadvantages of the different types of pipe. Pages 430 and 42 Modern Agricultural Mechanics.
 - b) "Comparison Among Copper, Galvanized and Plastic Pipe in Relation to Selection Factors" - twelve selection factors were compared and tabulated. See HO #1 and TM #4.
2. Let the students handle the different pipe fittings to see the angles, threads, coupling methods, and functions.

What are the different types of pipe fittings?

- 1) Pipe fittings
 - a) Used to join sections of pipe together
 - b) Reduce size of pipe
 - c) Change direction
 - d) Close the ends of pipe
- 2) Union (galvanized steel and copper)
 - a) Used to join two pieces of pipe when neither can be turned
 - b) Used when a part of a system will have to be removed for replacement
- 3) Couplings (galvanized steel, copper brass)
 - a) Used to connect straight lengths of pipe
 - b) Plain couplings connect the same size pipe.
 - c) Reducing or enlarging couplings are used when pipes of different sizes or material (i.e., copper to brass to galvanized) are to be connected.
- 4) Elbows (galvanized copper)
 - a) Used to change the direction of pipe run
 - b) Comes in either 45- or 90-degree angles
 - c) May be the same size on both ends or reduced on one end

- 5) Street elbows (galvanized)
 - a) Threads on the outside of one end and on the inside of the other
 - b) Used for making close turns from tanks, boilers and fittings
- 6) Tees (galvanized, copper, brass)
 - a) Used for branching off from the main pipe line
 - b) May be plain, reducing or street
 - c) May have one or two openings of a different size
- 7) Crosses (galvanized, copper, brass)
 - a) Used for branching off in opposite direction from the same point in a pipeline
 - b) May be plain or reducing
- 8) Nipples (galvanized)
 - a) Short lengths of pipe with threads on both ends
 - b) Used to connect two fittings
 - c) Classified as close, short or long
- 9) Bushings (galvanized, brass)
 - a) Used to make holes smaller in tanks, boilers, fittings, radiators
 - b) When some other type of reducer cannot be used
- 10) Plugs (galvanized, copper, brass)
 - a) Used to close the holes in tanks, boilers, radiators and fittings
- 11) Caps (galvanized copper, brass)
 - a) Used to close the end of pipe
- 12) Copper to galvanized adaptors (brass)
 - a) Used when copper tubing and galvanized pipe are jointed.
- 13) Rubber to galvanized adaptors (galvanized)
 - a) Used when rubber hose is joined to galvanized pipe
- 14) Hose connectors (galvanized, brass, soft metal)
 - a) Used to join two lengths of rubber hose
- 15) Clamps (steel)
 - a) Used to secure rubber hose to fittings
- 16) Globe valves
 - a) Used to control and vary rates of flow
- 17) Gate valves
 - a) Used only when the pipe is to be either fully opened or fully closed
 - b) Not used to vary fluid flow
- 18) Angle valves
 - a) Used to change flow direction 90 degrees
- 19) Stop and waste valves
 - a) Have a small drain cock on the outlet side so that when the valve is closed the outlet side of the pipeline may be drained to prevent freezing

- 20) Frost-proof valves
 - a) Used in cold climates
 - b) The cutoff is placed below the frost line.
 - c) Water drains out of the outlet pipe automatically when the valve is closed.
- 21) Check valves
 - a) Automatic valves that allow the fluid to flow in only one direction
 - b) Prevent the fluid from draining back when the pressure is released
- 22) Compression valves
 - a) The most common type of valve found in home, examples are sink, lavatory, and hose faucets
 - b) Shut off the flow by pressing a rubber washer against a seat
 - c) Used to vary and to shut off flow
- 23) Galvanized steel
 - a) Used when connecting rubber hoses into galvanized fittings
- 24) Brass fittings
 - a) Used when there is a danger of electrolysis between two different metals
 - b) Example: Copper tubing cannot be joined directly to galvanized materials; therefore, copper tubing is sweated into a brass fitting which is in turn connected to galvanized fittings.
 - c) Most are brass so that they will last longer.
 - d) Rust will not impair their functioning.
 - e) Rust deposits build up on the inside of galvanized fittings, and copper sometimes is too soft to be used.
- 25) Copper fittings
 - a) Used when joining copper tubing to copper tubing
 - b) Two types of copper fittings
 - i) The first needing a flared end and consisting of a tubing nut and the fitting desired
 - ii) The second type requires a heat source and resin-core solder.
 - c) The tubing slips into the fitting and then the joint is heated; solder is applied to make it airtight.
- 26) Types of copper fittings
 - a) Couplings
 - b) Elbows
 - c) Street elbows
 - d) Tees
 - e) Crosses
 - f) Nipples
 - g) Bushings and reducers
 - h) Unions

- i) Plugs
- j) Caps
- k) Transition fittings
- l) Globe valve
- m) Faucet

3. Prepare examples of the different methods of connecting pipe together. Include threaded pipe, lead-oakum cast pipe, soldered pipe, solvent-joined pipe, compression-joint copper or plastic pipe, and clamped joint.

How do the fittings differ according to the pipe type?

- 1) Black and galvanized pipe
 - a) Fittings used are threaded either on the outside or inside.
 - b) Requires more tools and time than some of the other types
- 2) Cast-iron pipe
 - a) Fittings are not threaded.
 - b) The joints are sealed by a combination of oakum (hemp) packed first.
 - c) Molten lead used to fill the spacing.
 - d) Caulk used to seal the entire joint; this is necessary because the lead shrinks when it cools
- 3) Copper pipe
 - a) Joined in two ways, by soldering and flaring
 - b) They each have their own fittings.
- 4) Joining copper pipe
 - a) Soldering requires a smooth fitting that allows the pipe to enter with only a little space. Flux is used to draw hot solder into joints to make a strong bond.
 - b) Flaring requires special equipment that expands the end of the copper tubing so a special compression fitting can be used to make a light solderless joint.
 - c) Plastic pipe is joined according to the type of plastic of which it is composed. There are three methods used:
 - i) Solvent
 - ii) Insert
 - iii) Flare
- 5) When using PVC or CPVC the plastic must be primed with a recommended primer and then solvent cement is added to seal the fitting and pipe together.
- 6) PE tubing is more flexible and uses insert fittings held watertight by stainless steel clamps. The fittings are scalloped to assure a tight fit.

F. Summary

Due to modern technology the plumber of today has the option of using many different types of pipe and pipe fittings. Each has its strengths, weaknesses, and methods of installation. Study the methods carefully to make the best choice of products.

G. Evaluation

Set up an identification test with the following categories represented.

- 1) Pipe
- 2) Fittings
- 3) Joining materials

Copper Fittings

TM-1



Adapters



Sanitary Tee



Soil-Pipe Adapter



1/4 Bend



Cleanout with Plug



Reducing Coupling



Coupling

Plastic Fittings



Sanitary Tee with Side Inlets



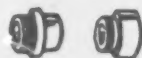
P-Trap



Plug



Sanitary Tee



Trap Adapters



1/4 Bend



Reducing Coupling



Cleanout Adapter



Bushing



Coupling



Closet Flange

Cast-Iron Pipe and Fittings



Cleanout Ferrule
with Plug



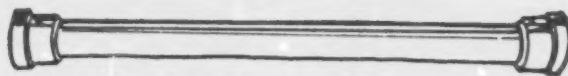
Reducer



Drum Trap
with Cover



Slotted
Closet Flange



Double-Hub Pipe (5')



Cleanout Tee



Roof Flashing



1/4 Bend



Floor Drain



Single-Hub Pipe (5')



Tapped
Sanitary Tee



45° Wye



Vent Tee
Tapped



Sanitary Tee
with Side Tap

Cast-Iron Fittings

TM-3



1/4 Bend



Sanitary Tee



Tapped
Sanitary Cross



Reducer



Closet Bend



Cleanout Plug



Coupling



45° Y



P-Trap

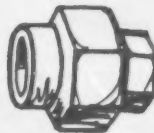
Steel Fittings



90° Ell



Bushing



Union



45° Ell



Plug



Tee



Hose Adapter



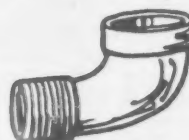
Reducer



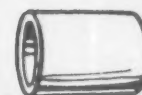
Reducing Tee



Cap



90° Street Ell



Coupling

Expansion and Contraction of Piping

Computed for pipe length of 20 feet.

Steel Pipe	Changes in length approx. .15'' with 100°F change in temperature.
Stainless Steel Pipe	Changes in length approx. .225'' with 100°F change in temperature.
Copper	Changes in length approx. .220'' with 100°F change in temperature.
PVC	Changes in length approx. .69'' with 100°F change in temperature.
ABS	Changes in length approx. 1.34'' with 100°F change in temperature.

Therefore some provision must be made for linear expansion and contraction of pipes and it is a different amount for different pipe materials.

Summary of Comparisons Among Pipe Types

Pipe Types	Copper	Galvanized	Plastic
Selection Factors			
A. Cost	Costlier per unit than plastic or galvanized	More costly than copper upon installation	Relatively cheaper than copper or galvanized
B. Resistance to puncture	Fairly resistant	Highly resistant	Types other than polyethylene (PE) are resistant to puncture
C. Resistance to corrosion	Not normally resistant	Corrodes in acid, hard water and alkaline. To minimize corrosion, add some phosphate compound	Highly resistant
D. Effect of soil type and pipe life expectancy	30 to 80 years under most soil conditions. - About 10 years in rocky soil 12 to 14 years in soils with high sulfur content	- Over 30 years under most soil conditions - Over 100 years if it transports water that contains corrosive substances - About 10 years in acid soils - About 12 to 16 years in waterlogged soils	- Research is still being conducted to ascertain its life expectancy - Experience tells us that plastic pipes endure most soil conditions
E. Ease of handling	- Heavy duty copper is hard to bend - Soft copper bends readily but collapses on short bends	Generally difficult to bend Slight bends over long lengths are fairly achievable	Bends readily but collapses on short bends
F. Effect on freezing	Withstands frozen conditions for a long time	Bursts easily	Withstands frozen conditions for a long time
G. Conductivity of electricity	Very conductive	Conductive	Non-conductive
H. Effect of sunlight	No effect	No effect	Negligible or minimal to no effect
I. Resistance to deposit formation	Absolutely resistant	Accumulates lime deposit from hard water	Absolutely resistant
J. Available lengths	- Types K, L, M and DWV hard copper are available in straight length usually 20 ft. long. - Soft copper tubing in types K & L comes in 20 ft. straight lengths or in long coils of 60 to 100 feet.	21 foot lengths	- Flexible polyethylene (PE) coils up to 400 feet - Rigid PE, PVC and ABS come in 10 and 20 foot lengths
K. Safe working pressures	Suitable for pressures used on farms and homes	- CPVC takes 100 psi at 180°F - PE takes 80 and 100 psi at normal temperature - Generally safe working pressures for plastics is limited at 73°F	
L. Effect of hot water	No effect	No effect	Chlorinated polyvinyl chloride - CPVC takes both hot and cold water - It is rated to take 100 psi at 180°F - Hot water affects other plastic type

PLASTIC PIPE MATERIALS

1. SR Styrene Rubber Plastic, Rigid pipe. 150 degrees F - no pressure. Uses: Septic tank absorption fields, storm drains and underground drainage. Joints by Solvent Cement and elastomeric seals.
2. PE Polyethylene, Flexible, Cold water service 100 degrees F and irrigation, joints by insert fittings and clamps.
3. PB Polybutylene, Flexible. Uses as for PE but will stand pressure at higher temperature 180 degrees F. Joins same as PE
4. PVC Polyvinyl Chloride, Rigid pipe, Cold water outside and inside buildings, DWV, irrigation, electric conduit, 100 degrees F, Joints: Solvent cement, Threading of schedule 80 and 120, Mechanical couplings, transition fittings.
5. CPVC Chlorinated Polyvinyl Chloride, Rigid pipe. Hot and cold water use. 180 degrees F, Joints as PVC.
6. ABS Acrylonitrile-Butadiene Styrene, Rigid pipe. Uses, DWV, Water piping (cold), electircal conduit. Joints same as PVC.

(NOTE: Where joints are made with solvent cement care must be taken to use cement specific for the plastic being cemented.)

UNIT - PLUMBING ON THE FARM

Lesson 4 - How are pipes measured, cut and joined together when constructing a plumbing system?

Objective: After completion of the lesson, the student will be able to measure pipe and fittings according to a diagram, cut the different types of pipe correctly, and be able to join like and dissimilar types of pipe.

Study Questions:

1. What factors must be considered before proper measurement of pipe systems can be accomplished?
2. How are the different types of pipe cut properly?
3. What methods are available to join different types of pipe together?

References:

1. Easy Home Plumbing, Nunn.
2. Modern Agricultural Mechanics, T.J. Wakeman. The Interstate Printers and Publishers, Danville, Ill.
3. Plumbing-Installation and Design, Ripka, American Technical Society.
4. Shopwork on the Farm, Mark M. Jones, McGraw-Hill Rural Activities Series.

Transparency:

1. TM #1: Table of Fitting Dimensions

UNIT - PLUMBING ON THE FARM

Lesson 4 - How are pipes measured, cut and joined together when constructing a plumbing system?

TEACHING PROCEDURE

- A. Review units on tools and fittings before attempting this unit.
- B. Motivation - Find out the cost of having a certified plumber install a simple water line and compare to the cost of materials alone.
- C. Assignment
- D. Supervised Study
- E. Discussion

1. Have the students measure and compare various pieces of pipe some with and some without fittings attached.

What factors must be considered before proper measurement of pipe systems can be accomplished?

- 1) Most pipe drawings show dimensions from the center of one fitting to the next. To determine the exact length of pipe to go between the fittings:
 - a) Find the distance the pipe screws into the fitting.
 - b) Find the distance from the center to the end of the fitting.
- 2) With these dimensions, the calculation of the exact length of pipe needed is simple:

Length of pipe = center-to-center of fitting - center to end of both fitting + distance pipe screws into both fittings.

A table of the dimensions of the fitting is in the back of this unit.

- 3) What you need to know is the type of fitting you will be using and the length of the run.
- 4) The depth a pipe penetrates the fitting will vary with the pipe size.
 - a) For 1/2-inch and 3/4-inch pipe thread, penetration is 1/2-inch.
 - b) For 1-inch pipe, penetration is 9/16-inch.
 - c) For 1 1/4-inch and 1 1/2-inch pipe, penetration is 5/8-inch.

- d) For 2-inch pipe, penetration is $11/16$ -inch.
- 5) An example: Using $1/2$ -inch pipe which will run between a tee and an elbow, which is 20 inches center-to-center
 - a) To do the measuring properly you need a ruler and a table of standard malleable fittings. See TM #1.
 - b) From the table get the center-to-end measurements for the fittings, in this case elbow or tee, and you find the value is $1\ 1/8$ inches for both. $1\ 1/8 + 1\ 1/8 = 2\ 1/4$ inches for fittings.
 - c) The distance into the fitting is $1/2$ -inch. So the length of pipe would be $20 - 2\ 1/4 + 1\ (1/2 + 1/2) = 18\ 3/4$ inches.

- 2. Set up a demonstration on how to cut the different types of pipe with the different tools. Be sure to include all safety practices and accessories available for use.

How are the different types of pipe cut properly?

- 1) Before cutting the pipe, it is essential that you:
 - a) Measure the pipe ahead of time.
 - b) Have a diagram of what you are trying to construct.
 - c) Have carefully planned the system to reduce the number of joints and thereby, save both money and time.
- 2) Cutting steel and copper pipe with a hacksaw
 - a) When cutting pipe with a hacksaw, you should use an 18 or 24 teeth-per-inch blade.
 - b) Carefully, notch the pipe with a file.
 - c) Then starting the cut in this notch make long, smooth strokes with medium pressure.
 - d) Too much pressure can ruin the blade.
 - e) Apply pressure on the downstrokes and release pressure on the backstrokes.
 - f) Be sure the work is secure before starting.
- 3) Cutting and reaming steel and copper pipe with a wheel-type cutter
 - a) The following are steps involved in cutting pipe:
 - i) Mark your pipe with a piece of chalk, soap stone or scratch awl.
 - ii) Place the pipe in the pipe vise with the mark far enough from the vise so that the cutter will clear the workbench.
 - iii) Fit the cutter over the pipe at the mark, and screw the handle in until the cutter wheel is pressing firmly against the pipe.
 - iv) Apply cutting oil to the pipe and cutter wheel.

- v) Rotate the cutter one complete turn. Then screw the handle in again about one-third a turn. Continue cutting until the cut is finished.
- vi) While the pipe is in the vise, ream the end of the pipe to remove the burr left by the pipe cutter. Small pipe (1/8" to 3/8") can be reamed more easily if it is cut with a hacksaw.
- 4) Two types of wheel cutters
 - a) One wheel for everyday normal cutting
 - b) Three wheel for hard to reach places
- 5) Reaming is essential because if the burr made while cutting the pipe is not removed:
 - a) It reduces the diameter of the pipe.
 - b) It will reduce the flow.
 - c) It increases pressure at the point of restriction.
- 6) To cut cast-iron pipe
 - a) Mark a cutting line on the pipe.
 - b) Use a hacksaw and make a groove at the mark about 1/16-inch deep, turning the pipe slowly to complete the groove all around the pipe.
 - c) Lay the pipe on a 2- by 6-inch board.
 - d) Use a cold chisel and hammer to tap around the groove.
 - e) Pound lightly, going completely around the pipe.
 - f) Continue this process until the pipe breaks.
 - g) Cast iron can also be cut with an assortment of mechanical cutters; squeeze type, ratchet type, and hydraulic type.
 - h) They all work on the principle of slow steady pressure.
- 7) Plastic pipe should be cut with:
 - a) A miter box
 - b) A very sharp tubing cutter with a special blade for cutting plastic. This is because if the end is not square, the pipe won't seat correctly in the fitting.
 - c) Be sure to remove the cutting burrs from the end of the pipe.

3. In this section we will be discussing in detail the methods for joining pieces of pipe. First review the measuring unit; then demonstrate the joining methods. Be sure to fully explain each step. The texts will lend some assistance.

What methods are available to join different types of pipe together?

- 1) The objective of each union
 - a) To have a tight joint that will prevent the leakage of water, air, gas or whatever will be running through the pipes

- b) Each method has its own purpose as well as advantages and disadvantages so consider these before jumping into the methods.
- 2) The steps in threading pipe are as follows:
 - a) Check to see that you have the proper size die and guide and that the die is properly adjusted.
 - b) Place the pipe in the vise, with the end projecting far enough through the vise for the pipe stock to clear the workbench or vise stand.
 - c) Use thread-cutting oil (lard oil). This makes a smoother thread, the die turns easier, and the life of the die is increased.
 - d) Start the thread by turning the die slowly clockwise until the die begins to feed itself.
 - e) Continue turning the stock slowly until the proper length of threads has been cut. For pipe up to 1" in diameter cut threads up to 1/4" beyond die. This gives about 3/4" of thread. For pipe one to two inches in diameter, the thread should project about 1/2" beyond die, giving threads about 1" long. Apply cutting oil at about every third turn of the die.
 - f) Try a fitting on the threads to check the depth.
 - g) Be sure to remove all metal chips from inside of the pipe. If left in, these will tend to cause pipes to clog and damage seats of valves and faucets.
- 3) Pipes can be connected by using a pipe wrench.
 - a) Adjust the wrench so that it will grip the pipe near the back of the jaws. Place the wrench on the pipe and apply pressure to the handle.
 - b) Press the adjustable jaw firmly against the pipe with one hand, and apply pressure on the handle with the other hand to make the teeth bite into the pipe. Continue turning the handle until it has made about a quarter turn.
 - c) Move the handle back to the starting position, and repeat step b. Continue in this manner until pipe is tight.
 - i) Check the adjustment of the jaws of the wrench occasionally to see if they still grip the pipe.
 - ii) The pipe threads are tapered because they will tighten securely as they are screwed into the fittings.
 - iii) Any threads that are cut after one thread projects through the die will not be tapered.

- iv) Be sure to clean the metal particles out of the dies after each cutting to prevent damage to the threads of the next piece cut.
- 4) Copper tubing is assembled according to its type or workability. The following types are available:
 - a) Type K--Supplied either in hard or soft temper is recommended for water, gas, steam and hot water systems, underground services and for industrial piping and other plumbing where there are relatively severe service conditions.
 - b) Type L--Also supplied in hard or soft temper and has the same general applications as Type K, but where relatively less severe conditions exist.
 - c) Type M--Supplied in hard temper only, and is recommended for interior heating and nonpressure applications, and for pressure applications where engineering design indicates its suitability. Hard tube in these types is commonly installed with solder fittings; soft tube with solder or flared tube fittings.
- 5) The type of solder used will vary on the service need of the tubing.
 - a) For all service at room temperature and for low pressure steam (up to 15 psi) as well as for moderate pressures with temperatures up to 250°F, a good grade of 50-50 tin-lead solder is more generally used.
 - b) For all temperatures up to 250°F, where higher strength is required, a 95-5 tin-antimony solder should be used.
- 6) The general types of fluxes used are of commonly available types. The fluxes suited to the 50-50 and 95-5 solders are in paste form and consist of a petroleum base, impregnated with zinc and ammonium chlorides.
 - a) It should not be the function of the flux to mechanically clean the copper.
 - i) The flux will be expected to remove residues of oxides.
 - ii) The flux protects the surface from further oxidation during the heating process.
 - iii) The flux floats out the remaining oxides ahead of the molten solder.
 - iv) Promotes wetting action of the solder.
- 7) Liquid fluxes may serve the purpose of removing oxides but generally do not perform the other purposes of a flux.

- a) In an effort to produce a liquid flux that will also clean the copper without manual cleaning, ammonia compounds must be used in dangerous amounts. For these reasons, none of the liquid fluxes now available can be recommended.
- 8) Recently developed paste-type fluxes claim cleaning before use is not necessary.
 - a) These have not been very successful.
 - b) Sometimes they may be considered satisfactory, but more often they are uncertain in their results and the repair of a few leaks will cost much more than can be saved by eliminating the mechanical cleaning.
- 9) It cannot be too strongly emphasized that for strong, tight, long-lasting joints, thorough cleaning of the surface and the inside of the cup of the fitting is of the utmost importance.
- 10) Pretinning is not necessary and generally is not recommended.
- 11) If the metal is properly cleaned and fluxed, capillary action should draw all the solder needed for the joint. Therefore, it is possible that pretinning may interfere to some extent with the capillary action.
- 12) Fittings that are oversized will result in a loose fit.
 - a) Capillary action is dependent on a fairly tight fit.
 - b) A certain amount of looseness can be tolerated, but it is more apt to cause difficulties in the large sizes.
 - c) This is particularly true for the horizontal joints, where an oversize fitting may allow the tube to rest directly on the socket, resulting in a double-width space at the top.
 - i) Wherever possible, such joints should be made up in the vertical position before assembly.
 - ii) However, for best results use fittings conforming to accepted standards.
- 13) After the preliminary preparations of measuring, cutting, burr removing, there are six simple steps in making a joint:
 - a) Clean tube end and socket of fitting.
 - i) Surfaces to be joined must be clean and free from oil, grease and heavy oxides.
 - ii) The end of the tube should be cleaned for a distance only slightly more than it is to enter the socket of the fitting.
 - iii) Fine sand cloth (preferred), steel wool or special wire brushes may be used.
 - iv) Rub hard enough to remove the surface soil, taking care not to remove the copper itself.

- v) If the cleaning is done on work in place, care should be taken that particles of steel wool or other material do not fall into and lodge in either tube or fitting.
- vi) The socket of the fitting should be similarly cleaned, and the same precautions should be observed. Even if the socket looks clean, clean it anyway.
- b) Apply flux to the cleaned areas.
 - i) As quickly as possible after cleaning, the surfaces to be joined should be covered with a thin film of flux.
 - ii) The preferred flux is one that is mildly corrosive, containing zinc and ammonium chlorides in a petroleum base.
 - iii) Use solder flux brushes to apply the flux for an even distribution.
- c) Assemble.
 - i) Insert the tube into the fitting.
 - ii) Make sure that the tube is against the stop of the socket.
 - iii) A small twist will help to spread the flux over the two surfaces.
- d) Apply heat and solder.
 - i) Heat may be applied by gas-air torch, propane torch, or by a blow torch. To heat as large an area of the fitting as possible, move the flame back and forth on the fitting. Avoid pointing the flame into the socket. When the metal is hot enough, the flame should be moved away and the solder should melt on contact with the tube.
 - ii) Avoid overheating, which may burn the flux and destroy its effectiveness.
 - iii) When the joint is at the correct temperature, the end of the wire of solder is touched to the joint. Never apply the flame directly on the solder. It should melt on contact. The solder is drawn into the joint by the natural force of capillary attraction, regardless of whether the solder is being fed in upward, downward or sideways. If the joint has been properly made, almost instantly a ring of solder will be observed all the way around the joint.
- e) Remove residual solder and flux.
 - i) While the joint is still hot, remove surplus solder and flux with a wet rag or brush.
 - ii) This will improve the appearance of the assembly and remove any chance of continued corrosive action by the surplus flux.
- f) Allow joint to cool.

- i) The joint should be allowed to cool naturally for some time before applying water, particularly if cast fittings are used.
 - ii) Too rapid cooling has been known to crack cast fittings.
- 14) There are three basic methods that are used in the plumbing profession to join plastic pipes together. They are solvent welding, fitting-clamp joints and flare-fitting joints.
- 15) The first and most used method of joining plastic pipe is the solvent-weld joint. The primer and solvent work on the pipe to soften and fuse the pipe and fitting together. The finished product resembles an arc-weld joint. To get a good strong joint, three things are necessary:
 - a) Use the correct primer and solvent for the job.
 - i) Each type of pipe needs a different solvent.
 - ii) PVC and CPVC have to be primed first to clean the pipe properly.
 - iii) The others (ABS, etc.) only need the correct solvent.
 - iv) When you purchase the pipe, check the recommendations of the manufacturer for primers and solvents.
 - b) Have a good fit between the pipe and fitting.
 - i) Pipe to be solvent welded will have fittings that are tapered toward the bottom so that when the solvent softens, a tight fit with a large surface area will be bonded.
 - c) When you cut and install the pipe be sure to follow the directions carefully as to proper use.
 - i) ABS and PVC pipe are used for drainage, waste, and venting.
 - ii) CPVC can be used in pressure lines.
 - iii) Be sure to cut the pipe squarely.
 - iv) Remove all burrs with a knife or razor.
 - v) Check your fit so the pipe is fully into the fitting.
 - vi) Apply primer (if necessary).
 - vii) Apply the cement to both the fitting and pipe evenly.
 - viii) Put the pipes together immediately.
 - ix) Hold tightly for 10 seconds to allow the bonding to start.
 - x) Check for a ring of cement around the joint to insure a waterproof seal.
 - xi) Clean off the excess to keep the joint neat.

- 16) The second method of joining plastic pipe is insert fitting.
 - a) This method is used with flexible plastic pipe especially when installing temporary water lines.
 - b) To insert fittings:
 - i) Simply fit inside the pipe
 - ii) Can be softened by placing the end in warm water
 - iii) Then are held there by stainless steel clamps
 - c) They are best adapted to low pressure lines that deliver drinking water to animals.
- 17) The flaring method of connecting plastic pipe is very similar to the method used on copper tubing.
 - a) The pipe is held in the pipe clamp; then the round headed flaring tool is rotated 5 or 10 times to complete the flare.
 - b) Match the flare to the fitting and tighten the locking to insure a tight fit.
 - c) This method can be used on the less flexible pipe for higher pressure lines.
- 18) Be sure to use the recommended fluxes, solvents, primers and tools to join the pipes together. There are different methods for different jobs and if any questions arise, your distributor of plumbing supplies should have the specifications that you need.

F. Summary

1. Know how to measure pipe before attempting to install a water system.
2. Each type of pipe has individual characteristics that make it the best suited for the job. Be sure to compare the characteristics before purchasing.
3. Cutting methods you use will vary according to your individual needs. For a simple water system only a hacksaw and file are needed, and for large jobs, tools designed specifically for the purpose of cutting and reaming, would save time and effort.

G. Evaluation

Answers to the exam

1. Length of pipe = center-to-center of fitting (distance needed) - center-to-end of both fittings + distance pipe penetrates both fittings.
2. a. Hacksaw
b. Pipe cutter - wheel type
3. a. Float particles of metal

- b. Lessen heat
- 4. Any two of the following:
 - a. Increase flow
 - b. Better fit
 - c. Lessen damage
- 5. a. Type K - hard or soft
 - b. Type L - hard or soft
 - c. Type M - hard only
- 6. a. Tin
 - b. Lead
- 7. Any two of the following:
 - a. Clean oxides
 - b. Promotes wetting action of solder
 - c. Protects surface from oxidation

UNIT - PLUMBING ON THE FARM

Lesson 4 - How are pipes measured, cut, and joined together when constructing a plumbing system?

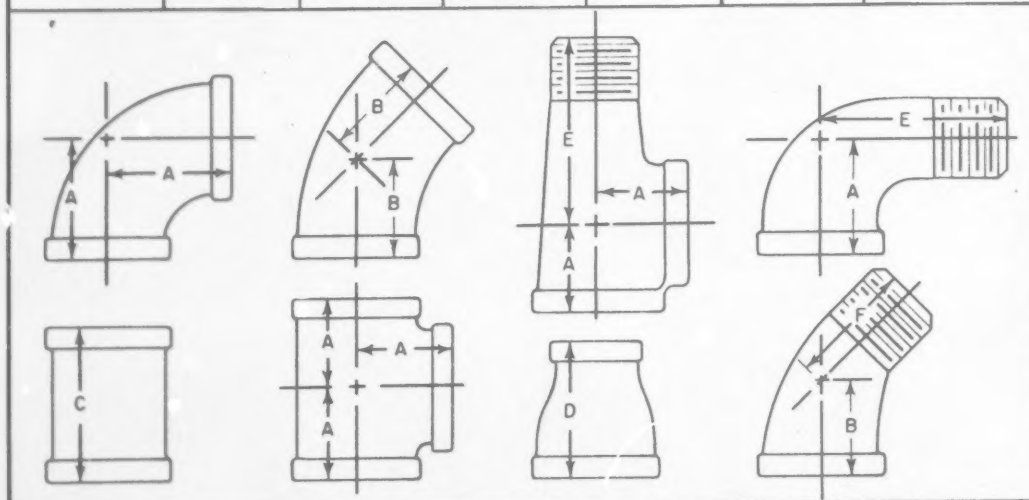
EXAM

1. What is the formula for determining a length of pipe?
2. Name two methods for cutting steel or copper pipe.
 - a.
 - b.
3. What are the two functions of lard oil when cutting pipe?
 - a.
 - b.
4. List two reasons for reaming pipe.
 - a.
 - b.
5. List the three types of copper tubing and indicate whether they are hard or soft.
 - a.
 - b.
 - c.
6. What are the two components of a 50-50 solder?
 - a.
 - b.
7. List two functions of flux.
 - a.
 - b.

Table of Fitting Dimensions

STANDARD MALLEABLE FITTINGS

Nominal Size (in.)	General Dimensions (inches)					
	A	B	C	D	E	F
$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	—	1	$\frac{1}{8}$
$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{4}$	$1\frac{1}{8}$	—	$1\frac{3}{8}$	$\frac{1}{8}$
$\frac{3}{8}$	$\frac{1}{8}$	$\frac{3}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{7}{8}$	1
$\frac{1}{2}$	$\frac{1}{8}$	$\frac{7}{8}$	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{5}{8}$	$1\frac{1}{8}$
$\frac{3}{4}$	$1\frac{1}{8}$	1	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{7}{8}$	$1\frac{5}{8}$
1	$1\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{1}{6}$	$1\frac{1}{6}$	2 $\frac{1}{8}$	$1\frac{7}{8}$
$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{5}{8}$	$2\frac{1}{8}$	$2\frac{7}{8}$	$1\frac{1}{6}$
$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{7}{8}$	2 $\frac{1}{8}$	$2\frac{1}{8}$	$2\frac{1}{6}$	$1\frac{7}{8}$
2	2 $\frac{1}{4}$	$1\frac{1}{2}$	2 $\frac{1}{2}$	$2\frac{1}{6}$	3 $\frac{1}{4}$	2 $\frac{1}{4}$
2 $\frac{1}{2}$	2 $\frac{1}{8}$	$1\frac{3}{8}$	2 $\frac{7}{8}$	3 $\frac{1}{4}$	3 $\frac{7}{8}$	—
3	3 $\frac{1}{8}$	2 $\frac{3}{8}$	3 $\frac{1}{8}$	3 $\frac{1}{6}$	4 $\frac{1}{2}$	—



STEEL AND WROUGHT-IRON PIPE DATA*

Nom. Outside Pipe Diam. Size	Standard		Extra Strong		Threads Per Inch	Tap Drill Size	Hole Size "	Length of Thread	Dist. Pipe Goes into Fitting
	Inside Diam.	Weight Lb. Per Ft.	Inside Diam.	Weight Lb. Per Ft.					
$\frac{1}{8}$	0.405	0.269	0.215	0.31	27	$\frac{1}{16}$	$\frac{7}{8}$	$\frac{1}{2}$	$\frac{1}{4}$
$\frac{1}{4}$	0.540	0.364	0.302	0.53	18	$\frac{3}{32}$	$\frac{7}{8}$	$\frac{1}{2}$	$\frac{1}{4}$
$\frac{3}{8}$	0.675	0.493	0.423	0.74	18	$\frac{1}{16}$	$\frac{7}{8}$	$\frac{1}{2}$	$\frac{1}{4}$
$\frac{1}{2}$	0.840	0.622	0.546	1.09	14	$\frac{1}{8}$	$\frac{7}{8}$	$\frac{1}{2}$	$\frac{1}{4}$
$\frac{3}{4}$	1.050	0.824	0.742	1.47	14	$\frac{1}{8}$	$1\frac{1}{8}$	$\frac{1}{2}$	$\frac{1}{4}$
1	1.315	1.049	0.957	2.17	11 $\frac{1}{2}$	$1\frac{1}{8}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$\frac{1}{2}$
$1\frac{1}{4}$	1.660	1.380	1.278	3.00	11 $\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$\frac{1}{2}$
$1\frac{1}{2}$	1.900	1.610	1.500	3.63	11 $\frac{1}{2}$	$1\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$\frac{1}{2}$
2	2.375	2.067	1.937	5.04	8	2 $\frac{1}{8}$	2 $\frac{1}{8}$	1 $\frac{1}{2}$	$\frac{1}{2}$
2 $\frac{1}{2}$	2.875	2.469	2.323	7.66	8	2 $\frac{1}{2}$	2 $\frac{1}{2}$	1 $\frac{1}{2}$	$\frac{1}{2}$
3	3.500	3.068	2.900	10.25	8	3 $\frac{1}{4}$	3 $\frac{1}{8}$	1 $\frac{1}{2}$	$\frac{1}{2}$

*All measurements are stated in fractional or decimal inches.

**Size of hole to drill to insert pipe through walls, floors, and other materials.

UNIT - PLUMBING ON THE FARM

Lesson 5 - How are water pipes protected from freezing?

Objective: After completion of this lesson, the student will be able to identify and install different methods of water-pipe protection from freezing.

Study Questions:

1. In respect to pipe freezing what factors must be considered before installing pipe?
2. What different methods are available to prevent pipes from freezing?
3. If your pipes do freeze, what methods are available to thaw them?

References:

1. Easy Home Plumbing, Nunn, 25-26.
2. Modern Agricultural Mechanics, T.J. Wakeman. The Interstate Printers and Publishers, Danville, Ill.

Transparencies:

1. TM #1: Laying Water Pipe and Installing Frost-proof Hydrants
2. TM #2: Heating Pipe

UNIT - PLUMBING ON THE FARM

Lesson 5 - How are water pipes protected from freezing?

TEACHING PROCEDURE

- A. Basic understanding of plumbing and electricity would be helpful.
- B. Motivation - How many of you (students) have ever had a pipe in your house or stock waterer on the farm freeze?
- C. Assignment - Identify different methods of water-pipe protection used in community.
- D. Supervised Study - Have the students insulate pipes and install frost-proof valves.
- E. Discussion
 - 1. When planning the on-farm-water system the builder must take into consideration the possibility of pipes freezing and bursting due to the expansion of water when it freezes. The factors to consider will be discussed below. See TM #1.

In respect to pipe freezing, what factors must be considered before installing pipe?

- 1) When running water pipelines from the pump to the buildings or waterers you need to bury the pipe below the frost line. Different areas have deeper lines so be sure to consult others in your area before setting the depth. Areas exposed to northerly winds will freeze deeper.
- 2) When planning the water system entrances to buildings, the pipe usually enters the building above the frost line and must be protected from the wind and cold.
- 3) How you run the pipes within the building is of major concern. Unless the building is well insulated or continuously heated, protection of the pipes will be necessary.
- 4) The properties of the type of pipe also must be considered. Copper pipe and plastic pipe will withstand frozen conditions much better than galvanized. But when using plastic pipe the cold will make the pipe very brittle. If frozen, plastic pipe is hard to thaw, because it is also flammable.
- 5) The type of system in respect to its use must be taken into account to allow the installer to select fittings that will drain below the frost line where needed and plan for heating in exposed areas.

2. The planning phase is important in that it allows the individual a chance to plan to prevent the freezing of water lines. See TM #2.

What different methods are available to prevent pipes from freezing?

- 1) Frost-proof hydrants are used outside in cold climates. The valves are located below the frost line and allow the water to drain out automatically when the valve is closed.
- 2) Stop and waste valves have a small drain cock on the outlet side so that when the valve is closed the outlet side of the pipeline may be drained to prevent freezing.
- 3) Pipes can also be protected from freezing by insulating them from the cold. This insulation can also be used on the hot water pipes to reduce heat loss. Some of the commonly used methods include:
 - a) In an unheated building, piping may be protected with a layer of felt or wool matting.
 - b) Commercial fiberglass insulation wrapped with a binding tape has use in insulating.
 - c) Molded insulation includes two halves that fit around the pipe with wire or metal strips to hold the halves together.
 - d) If pipes are already installed in a wall, mica or other loose-fill insulation can be poured into the wall from the top packing around the pipe.
 - e) Foam type insulation is extremely versatile in its application methods that range from rigid sheets, to malleable forms, to a sticky blown type that will stick to a surface or fill a space when dry.
- 4) Applying an external heat source to prevent freezing is used extensively in livestock waterers and on pipes exposed to the weather. The most used methods include: See TM #3.
 - a) On very cold days leaving a door open to an unheated area to prevent freezing
 - b) Placing a light bulb next to uninsulated pipes in confined areas. Some homemade waterers utilize this method by placing the bulb under the bowl and near the input pipe to keep the bowl and pipe thawed.
 - c) The use of 110-volt heating cables are now used more than ever. The method is simple and easy to install with the heat based on resistance wiring in contact with the pipe.

Timers and thermostats can be used to regulate the on and off times. The cables are not used to heat water but to provide just enough heat to keep the water in the pipes above freezing.

- d) An indirect method of heating the pipes would be to run the pipes overhead in areas of livestock concentration using the animal's body heat to prevent freezing.
 - 5) In building or areas serviced by the water system but not in use during the winter months, care should be taken to prevent water from freezing by draining all lines, emptying all water-storage units, and winterizing sink, tub or toilet traps. The winterizing can be accomplished by putting salt or antifreeze in the trap water to prevent freezing. The traps must be kept full to prevent combustible sewer gases from entering the building.
3. It is inevitable that one day every farm will face the problem of frozen pipes. For the sake of this discussion we will limit the problem to frozen, not broken pipes.

If your pipes do freeze, what methods are available to thaw them?

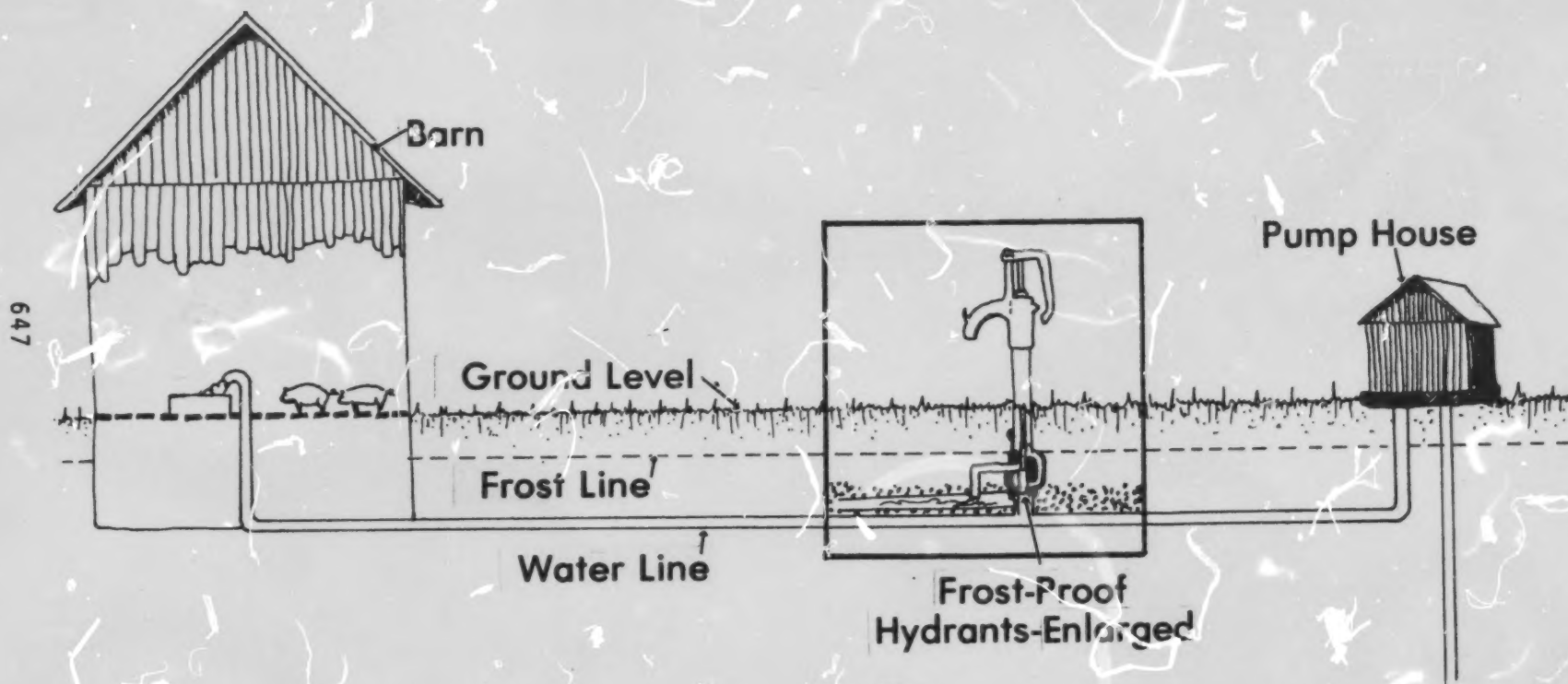
- 1) Frozen pipes are most easily thawed with electric-heating tape. Simply wrap the tape around the pipe and plug into a 110-volt outlet. The slow, steady heat thaws the pipes easily. It is safe with all types of pipe.
- 2) A propane torch may be used to thaw frozen METAL pipes. Work from an open faucet toward the frozen section. Otherwise, steam created within the pipe may cause the pipe to burst.
- 3) A heat lamp can be used to thaw pipes inside walls by heating the covering carefully. Be careful not to scorch the paint or wall covering.
- 4) The use of an arc welder to thaw pipes utilizes the principle of electrical friction. One lead is attached to one side of the frozen section and the second lead on the opposite side. In the case of a D.C. welder only one lead is needed letting the pipe be the ground. Low-amperage electricity passes through the pipe causing it to heat up and thawing the pipe. Remember the pipes are good conductors, so watch out for shocks.

Summary

The best way to cure the problem of frozen pipes is to plan for either insulating them from the cold or providing a heat source. Many methods of insulating against the cold are available as well as sources of heat for good water flow.

If a problem arises and the pipes do freeze they should be thawed out by a method suited to the situation.

Laying Water Line Pipe and Installing Frost-Proof Hydrants

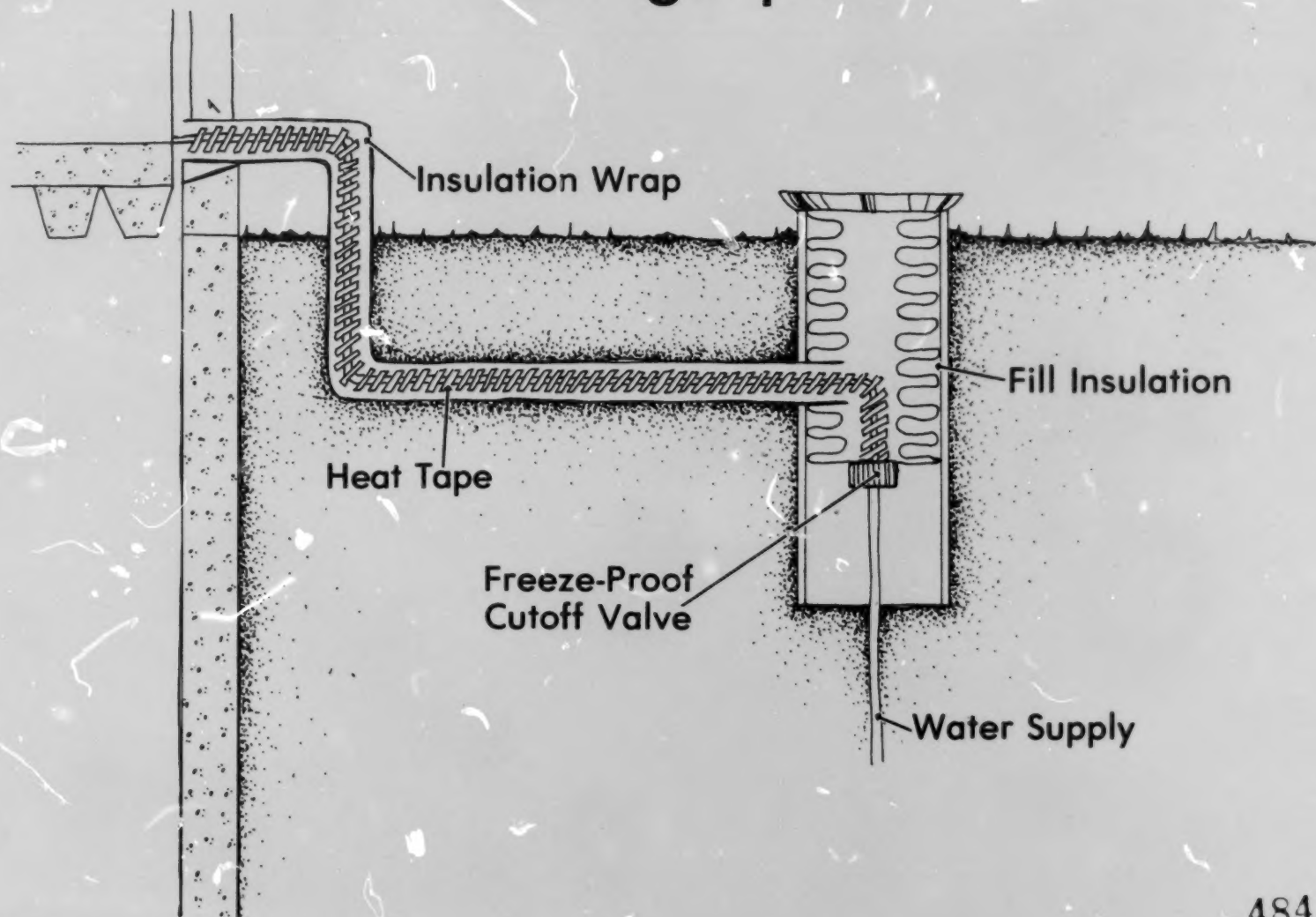


481

482

TW-1

Heating Pipe



649

483

484

TM-2

UNIT - PLUMBING

LABORATORY EXERCISE

Objective: At the conclusion of the exercise, the student will be able to measure, cut and join the different types of pipes to the satisfaction of the instructor.

Tools Needed:

1. Knife
2. Hack Saw
3. Screwdriver
4. Pipe cutter - copper, iron, plastic
5. Flaring tool - copper
6. 2 Pipe wrenches
7. Pipe threader with reamer

Materials Needed:

1. Hose adaptor - female
2. Hose clamps
3. Male adaptor polyethylene
4. Galvanized tees
5. 2 Polyvinyl chloride male adaptors PVC to galvanized
6. 90° elbow - PVC
7. 90° elbow - copper fitting
8. Hose bibb
9. Galvanized union
10. Galvanized coupling
11. Flare male adaptor - copper
12. Bottle of pipe compound, bottle of plastic cement, bottle of plastic pipe PVC cleaner

Pipe Required

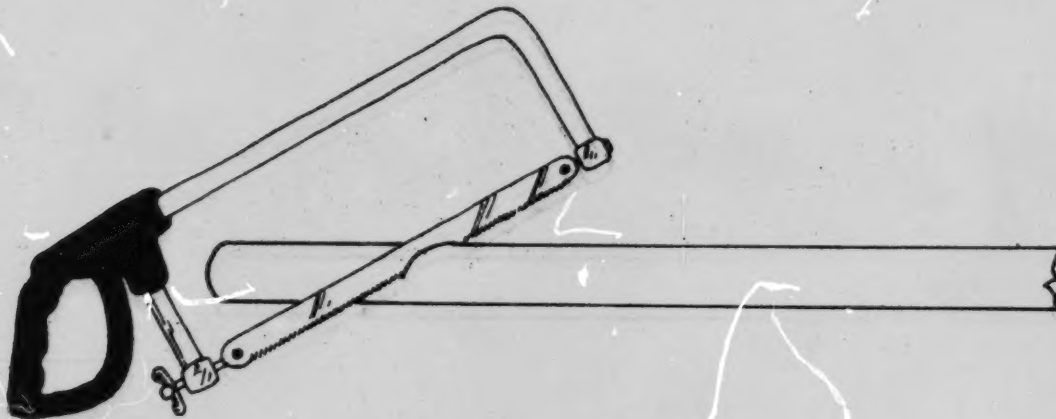
13. Polyvinyl (PVC) - $\frac{1}{2}$ -inch diameter
14. Copper type L tubing - $\frac{1}{2}$ -inch diameter
15. Galvanized pipe - $\frac{1}{2}$ -inch

(SPECIAL NOTE: This project was designed for maximum utility by the students and a minimum of cost to the school. For this reason, the length of each pipe section will vary because each student will be expected to reuse the pipe and pipe fittings of earlier students. Specifically, if a student used initial lengths of two feet per pipe section in the project, the next student would reuse the sections after the first student has dismantled his project and removed threaded or solvent welded pieces. A two feet piece of galvanized would now be: 24 inches - 1 to 2 inches for threads removed or a 22 inch piece ready for use. Solvent welded fittings are not removable and should be discarded.)

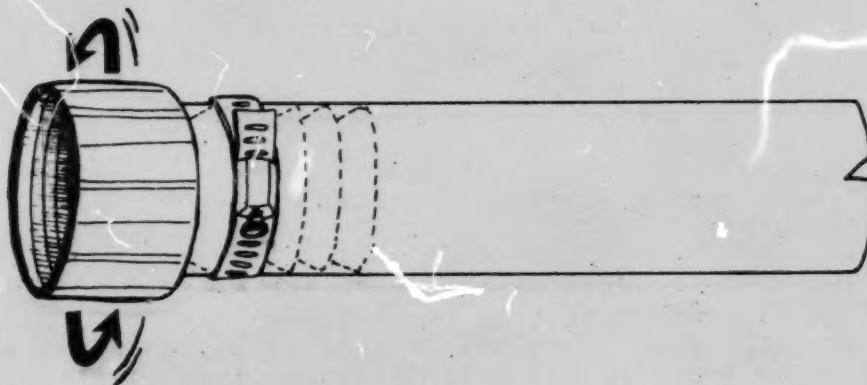
Procedure:

PART 1: POLYETHYLENE TO GALVANIZED TEE

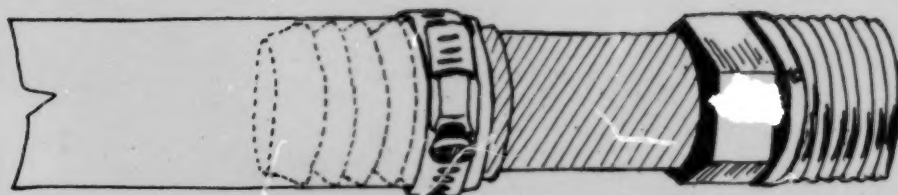
Step 1: Cut a section of polyethylene flexible pipe 2 or 3 feet long. Use a hack saw or sharp knife.



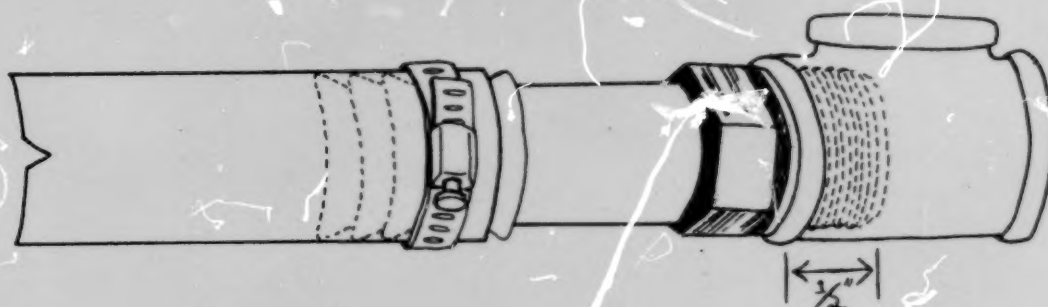
Step 2: Attach a hose adaptor to one end by inserting the male end into the pipe and seal with a stainless steel hose clamp.



Step 3: On the opposite end of the pipe insert the male end of the polyethylene to male galvanized transition adaptor into the pipe and seal with a stainless steel hose clamp.

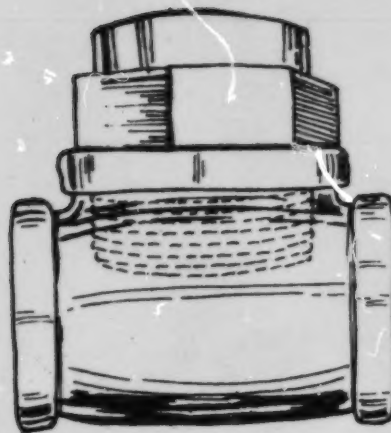


Step 4: Attach the galvanized pipe end of the adaptor to the galvanized tee. Use pipe compound to insure a tight seal.

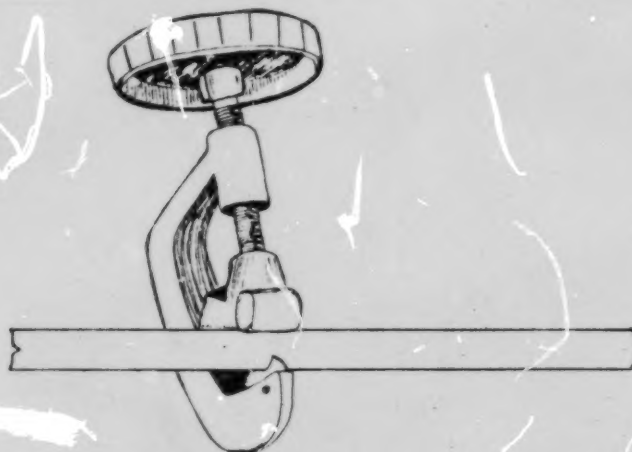


PART 2: GALVANIZED TEE TO PVC ELBOW

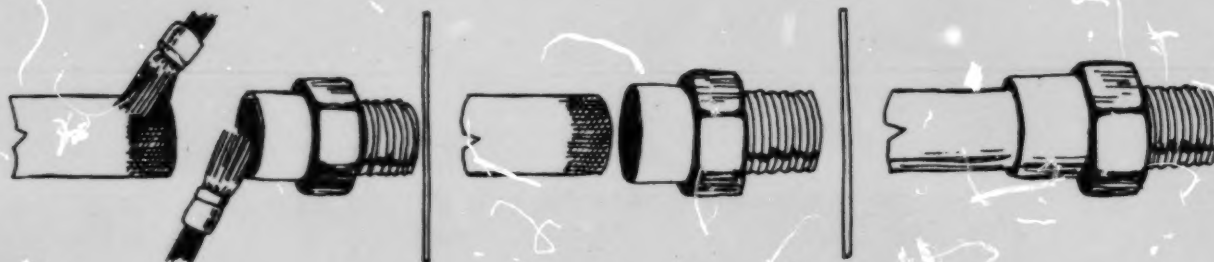
Step 1: Insert PVC male adaptor into the top of the galvanized tee. Use pipe dope for a secure fit.



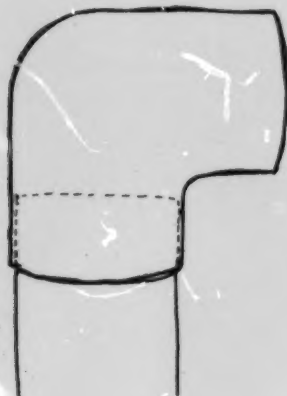
Step 2: Cut polyvinyl chloride to length decided by the instructor (the side length should be equal to the opposite side of the square). Use a hack saw or plastic pipe wheel-type cutter.



Step 3: Solvent weld the PVC pipe into the male adaptor. Use appropriate technique to insure a strong and watertight solvent joint.



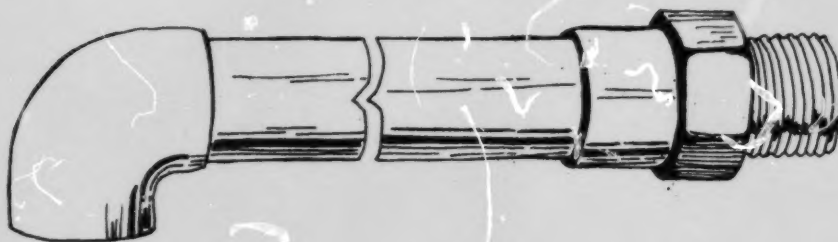
Step 4: Attach the PVC 90° elbow to the opposite end of the PVC pipe following the same procedure outlined in step 3.



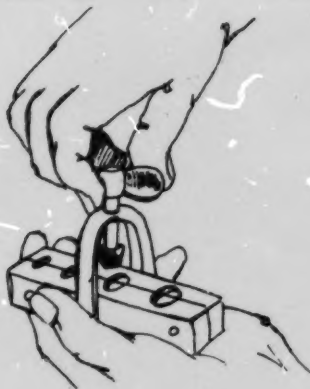
PART 3: FROM THE PVC ELBOW TO THE COPPER ELBOW

The distance from the center of the PVC 90° elbow and the copper 90° elbow should be equal to the distance from the center of one galvanized tee to the other galvanized tee. (Opposite sides of the rectangular pipe exercise should be of equal length.)

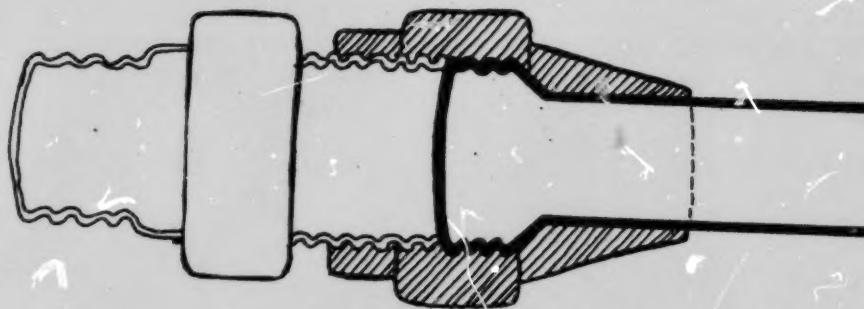
Step 1: Solvent weld the PVC pipe into the 90° elbow and the PVC male adaptor.



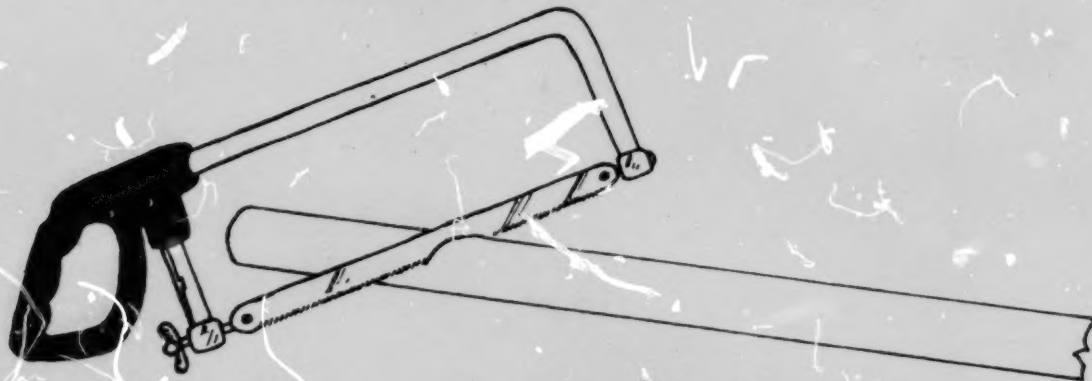
Step 2: Flare one end of the copper tubing. Be sure the flare nut has been placed over the tubing before flaring.



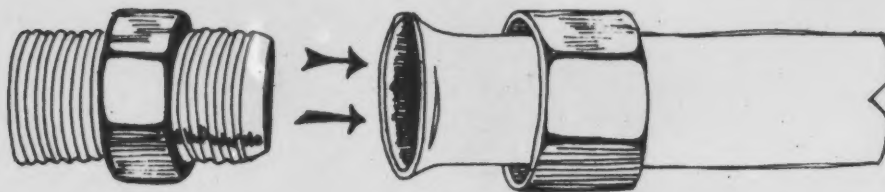
Step 3: Fit the flare end into the flare male adaptor.



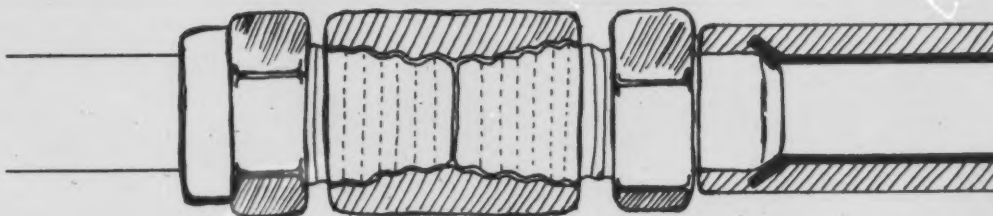
Cut tubing to size and use flaring tool to flare end of tube (be sure fitting is on before flaring).



Seat flared end carefully against fitting then tighten.

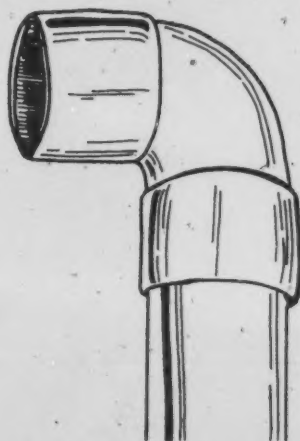


Step 4: Joint the PVC and copper together with a specially designed galvanized coupling. Use pipe compound to insure good sealing.



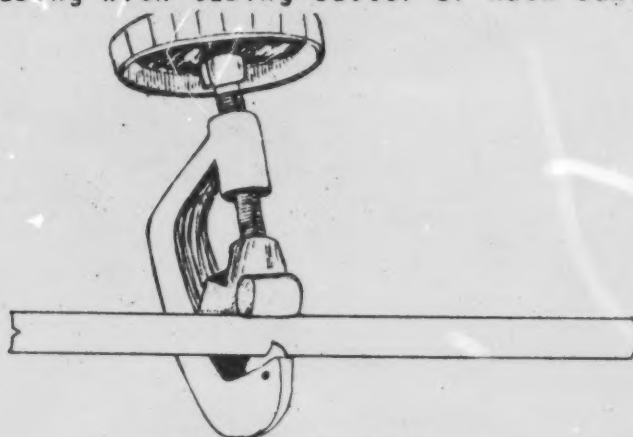
PART 4: COPPER 90° ELBOW TO HOSE BIBB

Step 1: Sweat solder the copper tube (equal in length to PVC side piece) into the 90° elbow.

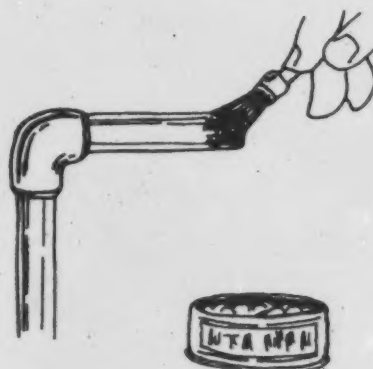


491

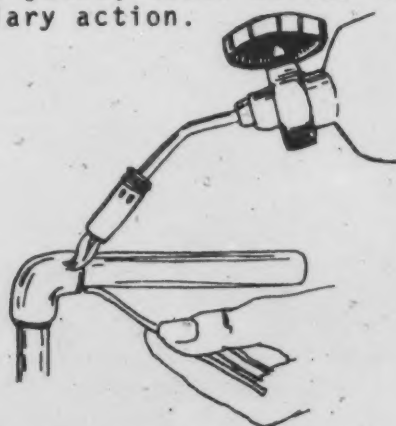
Cut tubing with tubing cutter or hack saw.



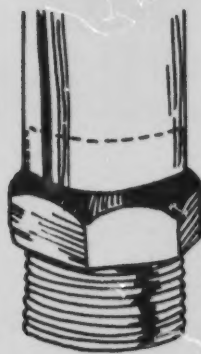
Clean copper tubing mechanically (emery cloth) and chemically (flux).



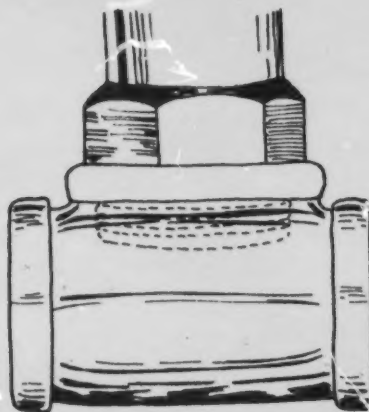
Sweat solder applying heat to joint, touch solder to joint, it will flow by capillary action.



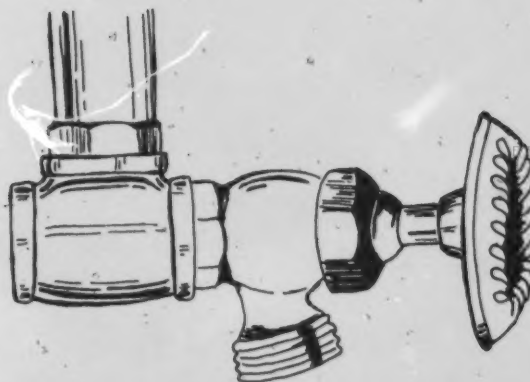
Step 2: Sweat solder the opposite end into a copper galvanized adaptor.



Step 3: Attach adaptor to galvanized tee.

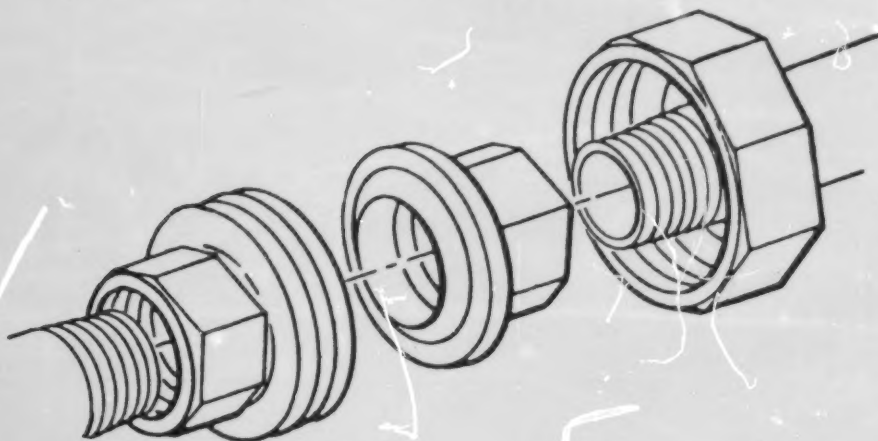


Step 4: Attach hose bibb to right side of the galvanized tee.



PART 5: TEE TO TEE

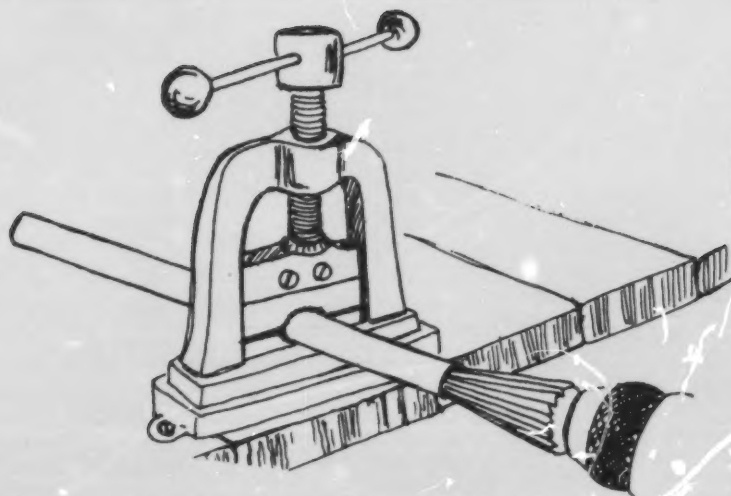
- Step 1: Measure the distance from the lip of the left tee to the lip of the right tee. Add 1 inch for threads that will penetrate the tees. Subtract for the size of the union minus 1 inch for thread length on each side.
- Step 2: Take the distance remaining and split the difference between the two galvanized sections of pipe.



- Step 3: Cut, thread and ream the galvanized pipe.
Clamp securely and cut with a smooth, slow motion



Ream the burr from the pipe. (See illustration on following page.)



Thread using liberal amounts of cutting oil.

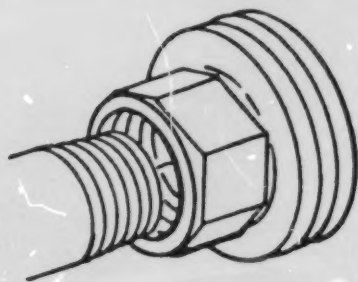


Use the proper tools when joining galvanized pipe. Remember, plastic will break if too much pressure is applied.

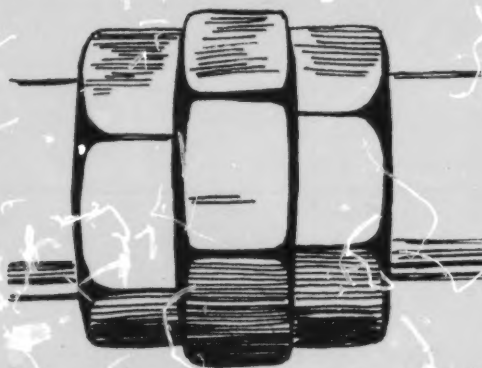


Step 4: Tighten the pipe pieces into the tees, use pipe dope!

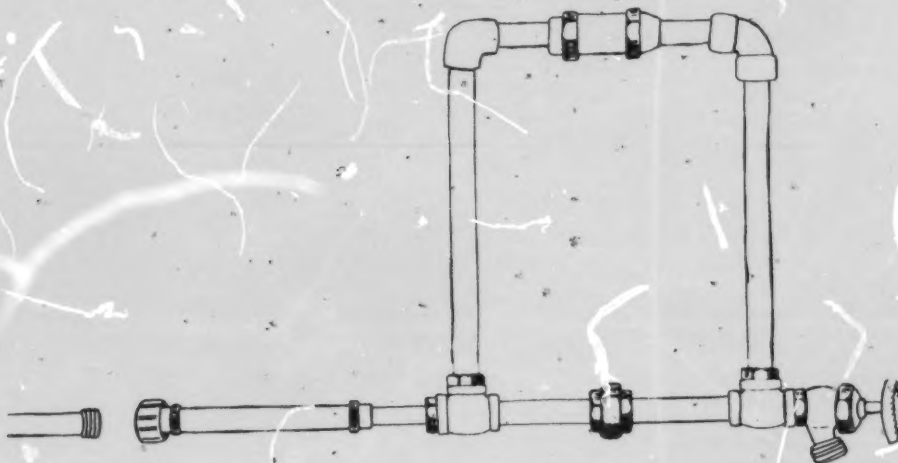
Step 5: Attach the union ends to the galvanized pipe.



Step 6: Tighten the center nut of the union.

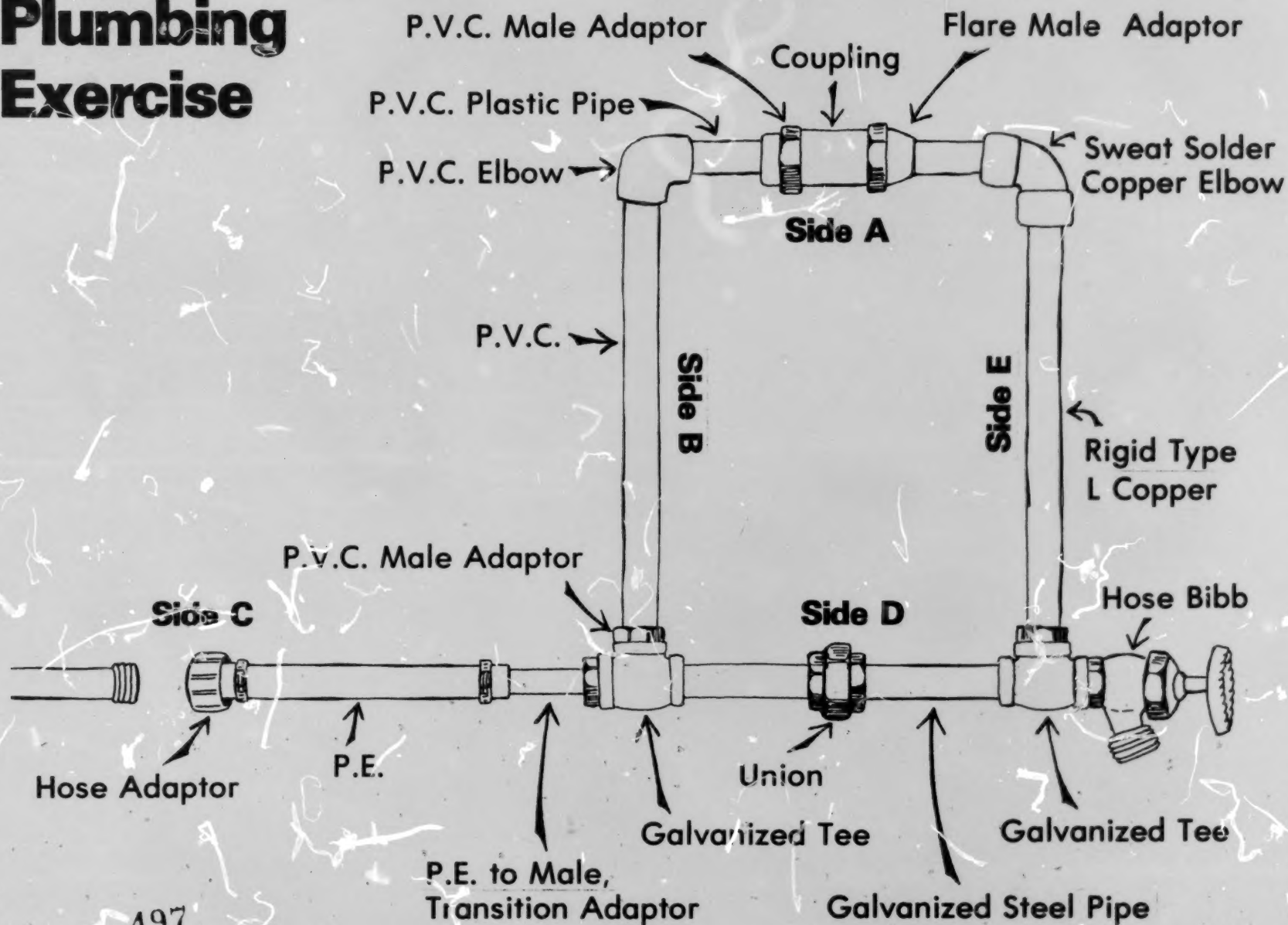


Step 7: Check to see if opposite sides are parallel.



Step 8: Fill with water and test under pressure for leaks.

Plumbing Exercise



UNIT - ALTERNATE ENERGY SYSTEMS

Lesson 1 - Which energy systems are currently being used and what is coming in the future?

Objective: By the conclusion of the lesson, the student will be able to identify current energy sources, look at their present situation, and identify future untapped energy sources.

Study Questions:

1. What are the prime energy sources for the U.S.?
2. What is the future of these sources?
3. What alternatives are available to the farmer?

References:

1. Construction Building Trades Solar Energy Techniques,
IML, UMC

Transparencies:

1. TM #1: Present Use of Energy
2. TM #2: Alternate Sources

UNIT - ALTERNATE ENERGY SYSTEMS

Lesson 1 - Which energy systems are currently being used and what is coming in the future?

TEACHING PROCEDURE

A. Review

B. Motivation - How many different energy sources are there? List on the board their answers. Set a black ball in the window and let it warm; then have students handle it.

C. Assignment - Locate in a magazine or newspaper an article about an alternate energy source and have them present the article in class.

D. Supervised Study - Review current farm magazines for articles on alternate energy.

E. Discussion

1. Currently we are drawing from limited natural resources for energy. We have been using these because of their accessibility and mobility but times are changing and these resources are running out. (Use TM #1.)

What are the prime energy sources for the U.S.?

- 1) The U.S. consumes more energy than any other country in the world.
- 2) Prime sources
 - a) Natural gas
 - b) Petroleum
 - c) Coal
 - d) Nuclear power (uranium)
 - e) Electricity (mostly generated using one of the above sources)

2. Our national consumption is very high and our resources are depleting rapidly. What do we have to look forward to? How long will these resources last?

What is the future of these resources?

- 1) Natural gas and petroleum are expected to be depleted by 1990's.
 - a) We are guilty of the doubling effect.
 - b) Doubling effect means we consume as much energy each decade equal to the sum of all past decades.

- 2) Coal is expected to last seven decades.
 - a) World's most abundant fossil fuel
 - b) Expensive to convert to electricity
- 3) Nuclear power (uranium)
 - a) Scarce resource
 - b) Life expected to be 15 years
 - c) Problems with waste
 - d) Problems with heated water runoff

3. There are alternatives now under experimentation on the farm. Although not perfected they do show promise for future applications. (Use FM #2.)

What alternatives are available to the farmer?

- 1) Solar (sun) energy is an endless supply.
- 2) Not a new idea has been used for over 1000 years
- 3) Sun can provide 35,000 times the amount of energy presently used by man.
- 4) Four objectives to using solar as a source
 - a) Collect radiation efficiently
 - b) Find a medium of transfer
 - c) Find a method of storage
 - d) Find a method of distribution
- 5) Other sources available
 - a) Wind power
 - b) Water power
 - c) Wood heat
 - d) Methane
 - e) Ethanol (Gasohol)

F. Summary

Our resources are dwindling in the areas of petrochemicals, coal and nuclear; and we need to find new sources of power. Also using an alternate method now could reduce farm dependency on present energy resources extending their lives.

G. Evaluation

Answers to the Exam

1.
 - a. Natural gas
 - b. Coal
 - c. Petroleum
 - d. Nuclear
 - e. Electric
2. Consumes each decade as much as in the last decades.
3.
 - a. Solar
 - b. Wind
 - c. Geothermal
 - d. Water
 - e. Wood
 - f. Methane
 - g. Ethanol

501

UNIT - ALTERNATE ENERGY RESOURCES

Lesson 1 - Which energy systems are currently being used and what is coming in the future?

EXAM

1. List the five prime energy sources currently used in the U.S.
 - a.
 - b.
 - c.
 - d.
 - e.
2. Define the Doubling Effect.
3. Name four energy alternatives to be prime sources.
 - a.
 - b.
 - c.
 - d.

Present Use of Energy

Electric Nuclear

Natural Gas

Petroleum

Gasoline

Coal

Alternate Sources

Wind

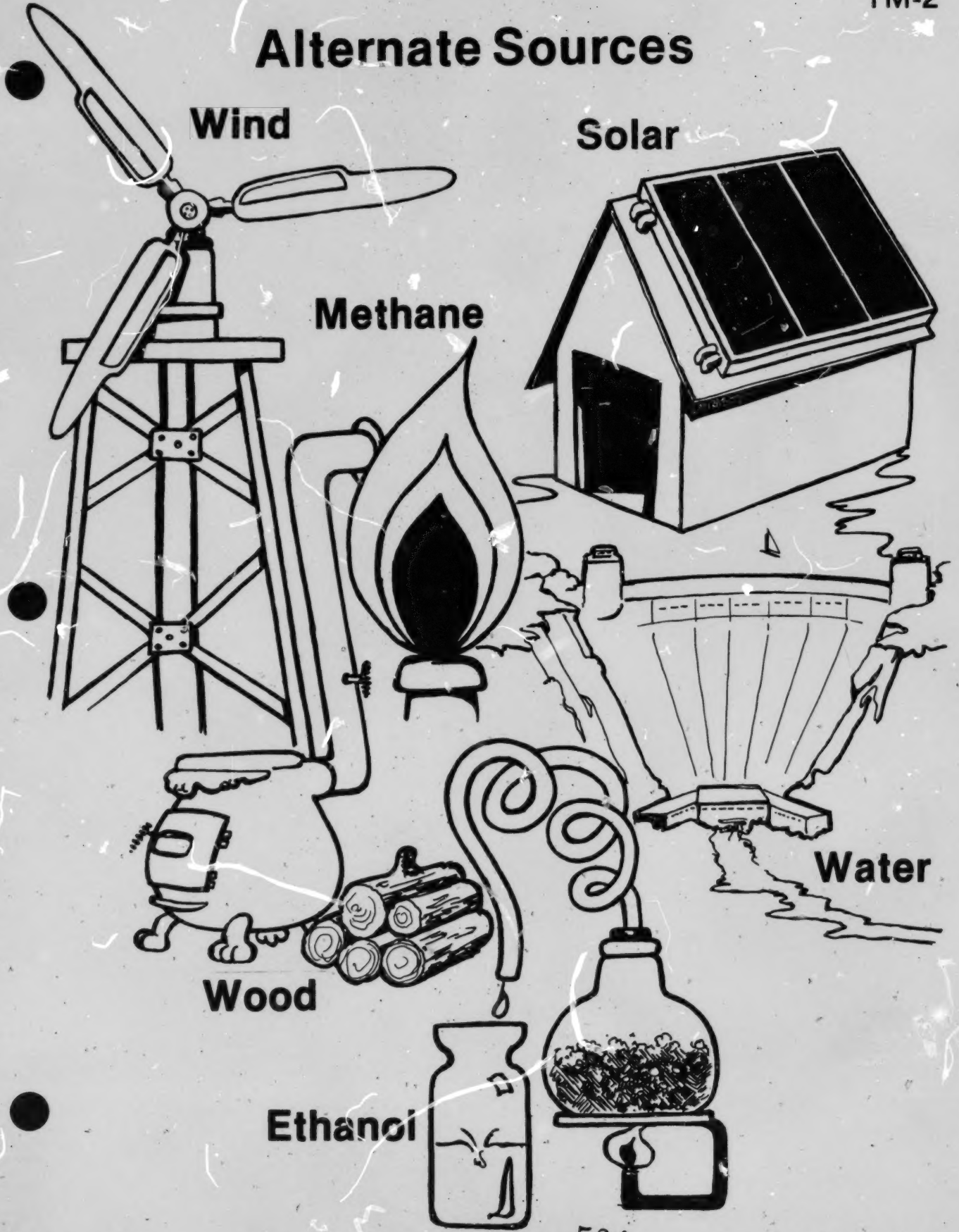
Solar

Methane

Water

Wood

Ethanol



UNIT - ALTERNATE ENERGY SYSTEMS

Lesson 2 - What are the basic solar principles that apply to agricultural building planning and construction?

Objective: By the conclusion of the lesson, the student will be able to define terms, orient a building to the sun, and identify the components of a solar system.

Study Questions:

1. What are the terms associated with solar construction?
2. What facts are important when planning for solar use in a structure?
3. What are the main components of a solar system?

References:

1. Construction Building Trades Solar Energy Techniques, IML, UMC
2. "Saving Energy With Passive Systems," UMC Guide #1972

Transparencies:

1. TM #1: Sun Path
2. TM #2: Parts of a Solar System

Handouts:

1. HO #1: Definition of Terms

UNIT - ALTERNATE ENERGY SYSTEMS

Lesson 2 - What are the basic solar principles that apply to agricultural building planning and construction?

TEACHING PROCEDURE

- A. Review lesson 1 on the four objectives of using the sun's energy.
- B. Motivation - What are the facts of a solar system? Is a wash tub set out in the sun a solar collector? Is a car with black interior a solar collector? How can we store heat the sun produces? Set a black ball or balloon in the sun to show solar absorption.
- C. Assignment - At home paint a surface black and another white. Touch the surfaces and feel the temperature difference after they have been set in the sun.
- D. Supervised Study - Perform the assignment as a group. Or use thermometers in two cans of water, one can silver, one black.
- E. Discussion
 1. In the last lesson we discussed briefly the four objectives for using the sun's energy: collection, transfer medium, storage, and distribution. To better understand these principles a working knowledge of the terms is necessary. (Use HO #1.)

What are the terms associated with solar construction?

- 1) Active systems - power involved in moving heat
- 2) Azimuth-bearing angle of collector, measured in degrees
- 3) Berm - a ledge or projection
- 4) Closed-loop system - transfer medium scaled in system
- 5) Conduction - movement through noninsulating material from heat
- 6) Convection - natural movement of molecules, heat up, cool down
- 7) Degree day - days a year where gain can be made from the sun
- 8) Equinox - time the sun crosses the equator
- 9) Greenhouse effect - collects heat, radiates to storage
- 10) Heat distribution - system to spread warmth naturally or artificially
- 11) Heat gain - amount of heat acquired from sun's radiation

- 12) Heat storage - method of holding heat for later use, i.e., water
- 13) Insulation - thermal protective substance
- 14) Medium of transfer - substance used to move heat
- 15) Open-loop system - fluid available for use, i.e., hot water
- 16) Passive system - natural flow of heat system
- 17) Skylight - building member that allows light into structure
- 18) Sun path diagram - charting the path of the sun to use when positioning building or collector.
- 19) Thermal mass - heat holding material, can be whole building
- 20) Thermosyphon - using hot air to heat storage material for later use
- 21) Thermostat - temperature sensing device
- 22) Tilt angle - collector angle to catch maximum sun
- 23) Vapor barrier - material that will limit the flow of moisture

2. There are several points of information necessary to determine before constructing a building where taking advantage of the sun will be part of the plan.

What facts are important when planning for solar use in a structure?

- 1) Radiation from the sun varies with time of year
 - a) June 21, maximum radiation
 - b) December 21, least radiation
- 2) Sun is 47 degrees higher in summer than winter due to 23 1/2 degree tilt of earth's axis
- 3) From knowledge of sun's location (Use TM #1.)
 - a) Can compute roof overhang length for shade
 - b) Can compute collector tilt angle for maximum heat gain
 - c) Can position structure for maximum solar gain
3. A solar system can be as simple as a window or as complex as a multi-pump computer controlled collector system. There are several components that are common to all systems and need to be considered to achieve maximum benefit from the sun. (Use TM #2.)

What are the main components of a solar system?

- 1) Collector heat gain
 - a) Amount of heat acquired from sun is radiation
 - b) The color of the collector is important: blue through black will gain 80 to 90 percent of the radiation
- 2) Medium of transfer
 - a) Fluid is the easiest to transfer and control.
 - b) Use a fluid chemically a better collector (refrigerant) to increase efficiency.

- c) Need a fluid that will release the heat easily
- d) Water is good but has freeze up problems in winter
- 3) Storage
 - a) Storage achieved by radiation, conduction, or convection
 - b) Try to use mass with several uses, i.e., rock
 - c) Large storage areas are thermal mass
 - d) Use a mass that can receive heat but is insulated to the outside
- 4) Distribution
 - a) Reradiation - most common
 - b) Convection
 - c) Conduction

F. Summary

A good understanding of the terminology and principles of solar systems will aid the builder in applying at least one of the energy saving ideas available from solar technology.

G. Evaluation

Answers to the Exam

- 1. e
- 2. a
- 3. c
- 4. b
- 5. d
- 6. Shade overhang, collector angle
- 7.
 - a. Collector
 - b. Medium of Transfer
 - c. Storage
 - d. Distribution

UNIT - ALTERNATE ENERGY SYSTEMS

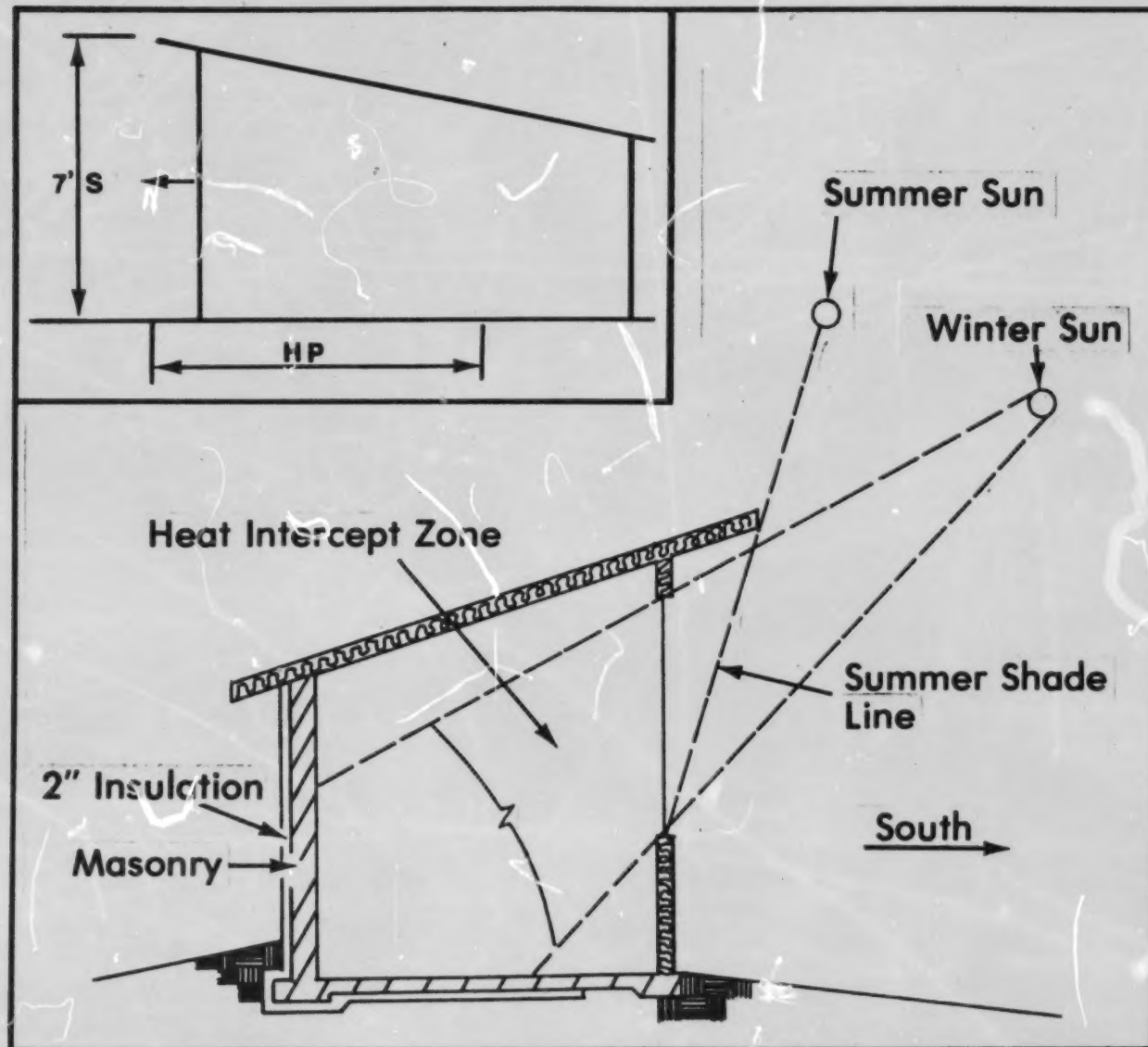
Lesson 2 - What are the basic solar principles that apply to agricultural building planning and construction?

EXAM

Match the term to its definition by writing the letter in the blank.

- | | |
|-------------------------|---|
| _____ 1. Conduction | a. Heat holding material |
| _____ 2. Thermal mass | b. Natural heat flow system |
| _____ 3. Convection | c. Natural movement of molecules |
| _____ 4. Passive system | d. Time sun crosses equator |
| _____ 5. Equinox | e. Movement through a non-insulating material |
6. From knowledge of the sun's location at different times of the year, we can compute _____ in the summer and _____ in the winter.
7. What are the four components of a solar system?
- a.
 - b.
 - c.
 - d.

Sun Path

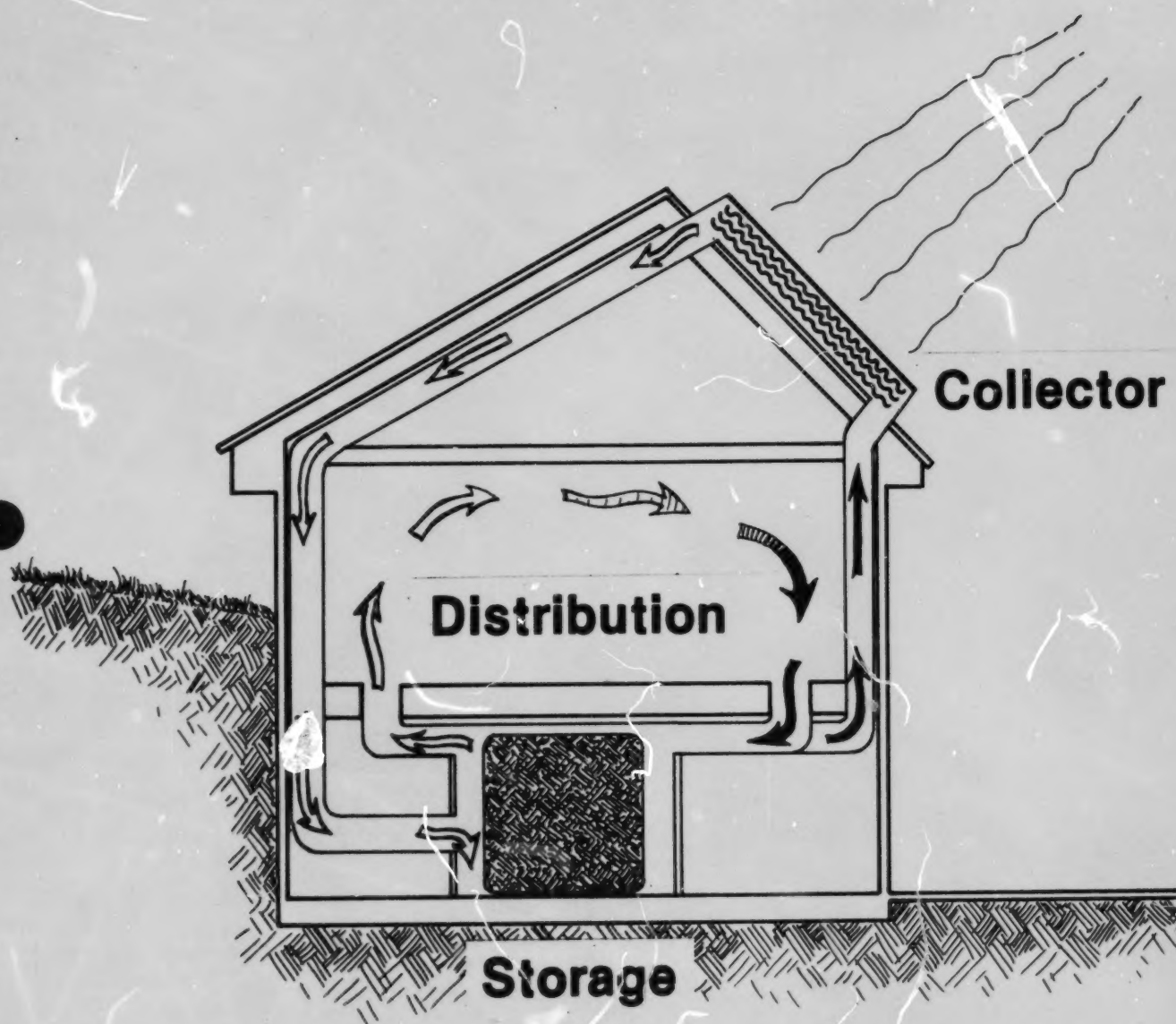


683

510

TM-1
511

Parts of a Solar System



DEFINITION OF TERMS

1. Active systems - power involved in moving heat
2. Azimuth - bearing angle of collector, measured in degrees
3. Berm - a ledge or projection
4. Closed-loop system - transfer medium scaled in system
5. Conduction - movement through noninsulating material from heat
6. Convection - natural movement of molecules, heat up, cool down
7. Degree day - days a year where gain can be made from the sun
8. Equinox - time the sun causes the equator
9. Greenhouse effect - collects heat, radiates to storage
10. Heat distribution - system to spread warmth naturally or artificially
11. Heat gain - amount of heat acquired from sun's radiation
12. Heat storage - method of holding heat for later use, i.e., water
13. Insulation - thermal protective substance
14. Medium of transfer - substance used to move heat
15. Open-loop system - fluid available for use, i.e., hot water
16. Passive system - natural flow of heat system
17. Skylight - building number that allows light into structure
18. Sun path diagram - charting the path of the sun to use when positioning building or collector
19. Thermal mass - heat holding material, can be whole building
20. Thermosyphon - using hot air to heat storage material for later use
21. Thermostat - temperature sensing device
22. Tilt angle - collector angle to catch maximum sun
23. Vapor barrier - material that will limit the flow of moisture.

UNIT - ALTERNATE ENERGY SYSTEMS

Lesson 3 - What are the passive solar systems and concepts?

Objective: By the conclusion of the lesson, the student will be able to identify the concepts of a passive system and describe the passive systems currently available.

Study Questions:

1. What are the concepts of passive solar heating and cooling systems?
2. What passive systems are currently available to use in structures?

Reference:

1. Construction Building Trades Solar Energy Techniques,
IML UMC

Transparencies:

1. TM #1: Passive Systems

UNIT - ALTERNATE ENERGY SYSTEMS

Lesson 3 - What are the passive solar systems and concepts?

TEACHING PROCEDURE

- A. Review the objectives of a solar system and the definition of a passive system.
- B. Motivation - Find a brick wall that faces south and have the students touch it on a sunny day. The warmth it absorbs is solar.
- C. Assignment - Have the students check their homes for possible solar use.
- D. Supervised Study - Discuss and list the possible application of passive solar systems to the school building
- E. Discussion

1. For a passive solar system to work the building must be heat tight.

What are the concepts of passive solar heating and cooling systems?

- 1) The caulking of all cracks where infiltration might occur keeps the structure energy tight.
 - 2) The structure walls and ceiling should be well insulated.
 - a) A minimum of R-19 should be used in the outside walls.
 - b) A minimum of R-24 should be used in the ceiling.
 - c) Insulation should also cover the back of ceiling joists to prevent infiltration through wood members.
 - d) All insulation should be located exterior to intended thermal mass.
 - 3) Install a vapor barrier of 6 mil polyethylene, not tar and felt paper.
2. There are several passive systems that can be built into new or pre-existing structures. They need to be considered in terms of space, insulation cost, and maintenance.

What passive systems are currently available to use in structures?

- 1) Water walls
 - a) Water walls absorb heat during the day and release radiant energy into the structure at night.
 - b) Water walls are usually constructed of drums, tubes, or canisters full of water.
- 2) Roof ponds, heating and cooling
 - a) Large polyethylene bags full of water are exposed to heat during the day and closed to the outside to reradiate energy into the structure at night during the winter months.
 - b) During the summer months, bags collect heat from the inside of the structure and then release that heat at night to the outside.
- 3) Trombe (massive masonry wall) wall, heating and cooling
 - a) The Trombe wall stores energy during the day by the greenhouse effect and generates convective currents into the structure for heat in the winter months.
 - b) At night, it then reradiates heat directly into the structure during the winter months.
 - c) During the summer months, convective currents formed from the greenhouse effect are released by vent to the outside drawing cool air from north windows into the structure for cooling.
- 4) Solar greenhouse, heating and cooling
 - a) The greenhouse works on a principle called the greenhouse effect.
 - b) The greenhouse collects heat and radiates that heat to storage and in the structure during the day of the winter months.
 - c) At night during those months, the storage releases energy into the structure for heat.
 - d) During the summer months, a convective current forms and is released through vents to the outside drawing cool currents through north windows.
- 5) Earth contact architecture
 - a) With large south facing windows, underground or bermed structures are heated by the greenhouse effect using the structural walls, floors, and provided thermal mass as storage.
 - b) At night during the winter months, thermal mass reradiates energy into the structure for heat.
 - c) There are several structural shapes that earth contact homes can take and still be very energy efficient.

- 6) Thermosyphoning
 - a) The sun's radiation heats an air collector during the day causing convective currents to heat both a storage unit and the structure.
 - b) The structure is heated at night during the winter months by the storage unit.
- 7) Passive solar systems should be the first step in designing any solar home including those utilizing active systems. If used properly, a solar home can be heated 100% by passive solar systems maintaining a mean temperature range of 54 to 70 degrees all year round.

F. Summary

A passive system makes use of the structure itself to absorb and store solar heat. The building design makes use of the sun and earth to provide low cost heating.

G. Evaluation

Answers to the Exam

1. T
2.
 - a. Water walls
 - b. Roof ponds
 - c. Trombe wall
 - d. Solar greenhouse
 - e. Earth contact
 - f. Thermosyphoning

UNIT - ALTERNATE ENERGY SYSTEMS

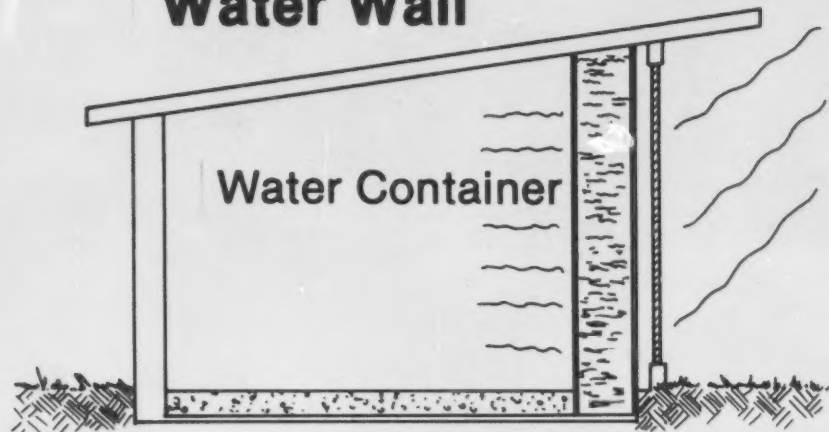
Lesson 3 - What are the passive solar systems and concepts?

EXAM

- T F 1. A vapor barrier is needed to prevent damage to the insulation from moisture.**
- 2. List and describe three passive systems.**
- a.**
 - b.**
 - c.**

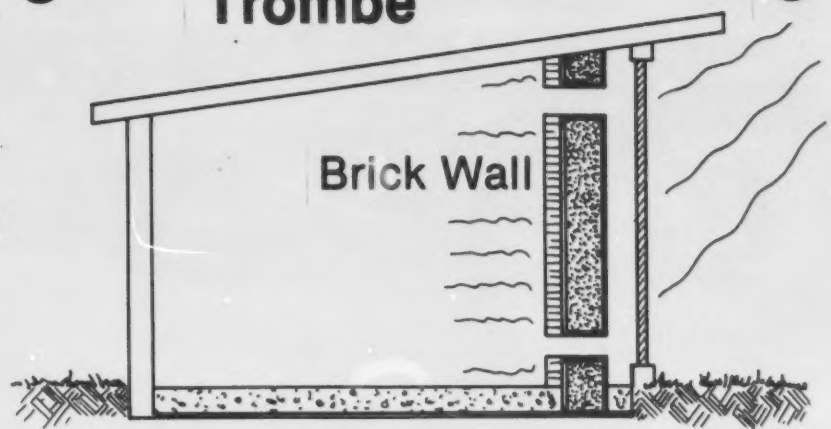
Passive Systems

Water Wall



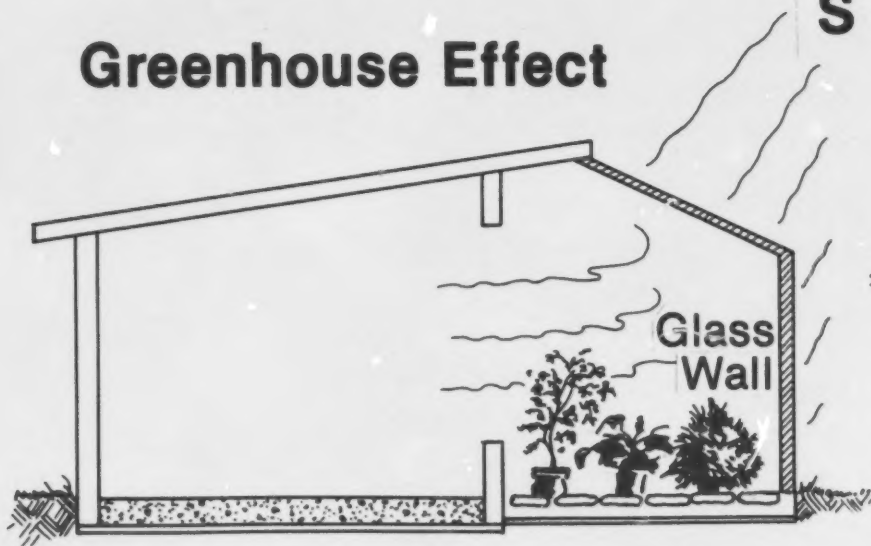
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Trombe



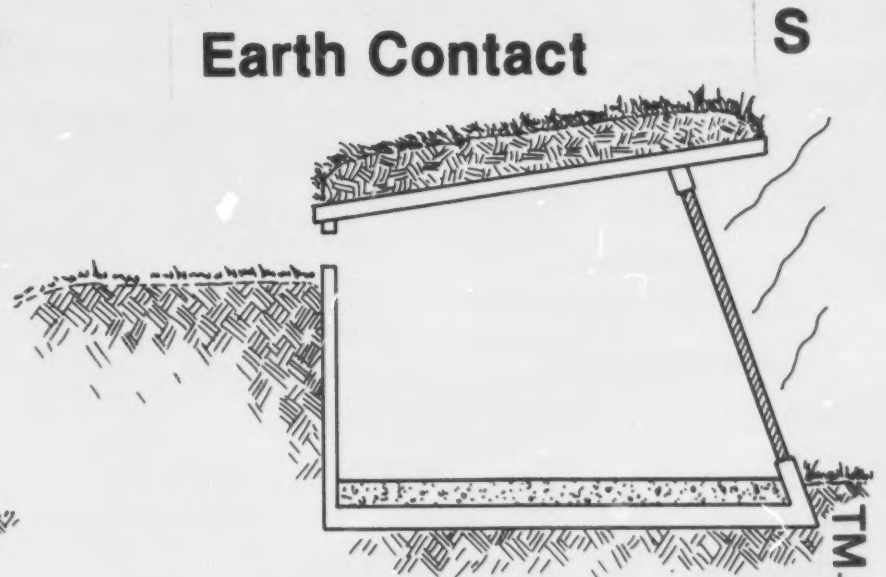
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Greenhouse Effect



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Earth Contact



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TM-1

UNIT - ALTERNATE ENERGY SYSTEMS

Lesson 4 - What are active solar systems and their concepts?

Objective: By the conclusion of the lesson, the student will be able to describe an open - and closed-loop system, and orient the structure and collector for maximum solar gain.

Study Questions:

1. What are active liquid solar systems and how do they function?
2. What are active air solar systems?
3. How should a structure and collector be oriented to achieve maximum solar gain?

References:

1. "Active Solar Collectors for Farm Building," UMC Guide #1971
2. Construction Building Trades Solar Energy Techniques, IML, UMC
3. "Model Solar System No. 1," UMC Guide # 1973

Transparencies:

1. TM #1: Water Collector and Concentrators
2. TM #2: Air Collector

Handouts:

1. HO #1: Efficiencies and Absorption
2. HO #2: Design Tips - Alternate Energy

UNIT - ALTERNATE ENERGY SYSTEMS

Lesson 4 - What are active solar systems and their concepts?

TEACHING PROCEDURE

- A. Review the terminology of solar before starting this lesson.
- B. Motivation - See if a local contractor deals in active solar systems and have him/her give a talk in class. Find a system in operation in your community. Build a simple hot-air system with a cardboard tube painted black; lay in the sun; after awhile blow in one end and feel the heat at the other end.
- C. Assignment
- D. Supervised Study
- E. Discussion
 1. In an active system the energy collected is forced out of the collector and not allowed to exit by convection. Several systems are available and will be discussed in this lesson. See TM #1.

What are active liquid solar systems and how do they function?

- 1) Open-loop systems
 - a) Open-loop systems are comprised of water, tubing, a pump, a storage tank, one way valve, collectors, thermistor, and other software controls.
 - b) Water is pumped into the collectors and heated providing heat for the storage tank and then to the blower system which is heating the structure.
 - c) This system is referred to as an open-loop system because the heated water can be used for a hot water radiant system or hot-water tank source and then the water is recycled by the pump.
- 2) Closed-loop systems
 - a) Closed-loop systems are different from open-loop systems in that they use antifreeze as a medium of transfer instead of water and therefore, require a coil in the storage tank to separate water used for a radiant system or hot-water tank source and the toxic antifreeze.

- b) The closed-loop system is so named because the antifreeze never leaves its cycle from the collector to the storage tank through the pump and back to the collectors. This is not the case with the water in the open-loop system.
- 3) Liquid systems use two types of collectors for heat gain.
 - a) Flat plate collectors which are usually stable (fixed) and are capable of generating temperatures of 180 degrees F even when the sun is not visible.
 - b) Concentrator collectors are collectors that must track the sun's path to receive maximum heat gain and are capable of generating up to 1000 degrees F but only on the days the sun is shining.
- 2. Active air systems use a forced air system to move collected energy. This is the less expensive of the two active systems and easier to design. See TM #2 and HO #1.

What are active air solar systems?

- 1) Active air systems work basically the same way as liquid systems except the medium of transfer is now air instead of fluid.
- 2) The air is heated by the greenhouse effect in the collectors, pumped to the storage unit and heating system of the structure, and then recycled to the collector.
- 3) Most common storage bins for active air systems use 2 to 3-inch rock or eutectic salt.
- 4) See HO #1 and #2 for design tips and absorption efficiency.
- 3. Even the best designed collector will not be completely effective if it is not oriented to the sun properly.

How should a structure and collector be oriented to achieve maximum solar gain? (See HO #2.)

- 1) For maximum collector gain, the collector tilt angle should be within 10 to 15 degrees of the site latitude with respect to the sun.
- 2) That same tilt angle should also be within 40 to 45 degrees of the horizontal plan of the site.
- 3) And the house axis, the axis based on due south, should be within 10 degrees west and 20 degrees east of due south or zero deviation.

- 4) In the case of pitched roofs that are excessively away from the norm, the collector tilt angle must still be maintained.
 - a) One solution could be to place collectors somewhere other than the roof.
 - b) Another solution could be to build separate supports for the collectors.

F. Summary

Active systems attempt to achieve maximum efficiency for the solar system by forcing the transfer of energy by artificial means. There are a number of systems commercially available.

G. Evaluation

Answers to the Exam

1.
 - a. Open-loop
 - b. Closed-loop
2.
 - a. Flat plate
 - b. Parabolic concentrator
3. 10 to 15

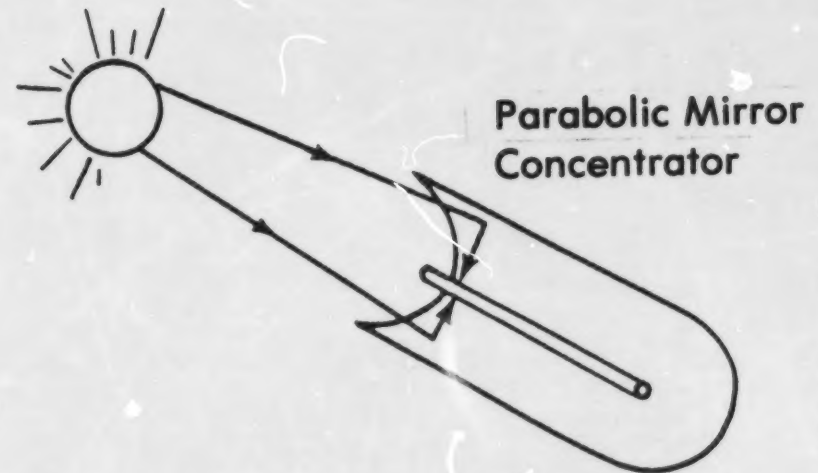
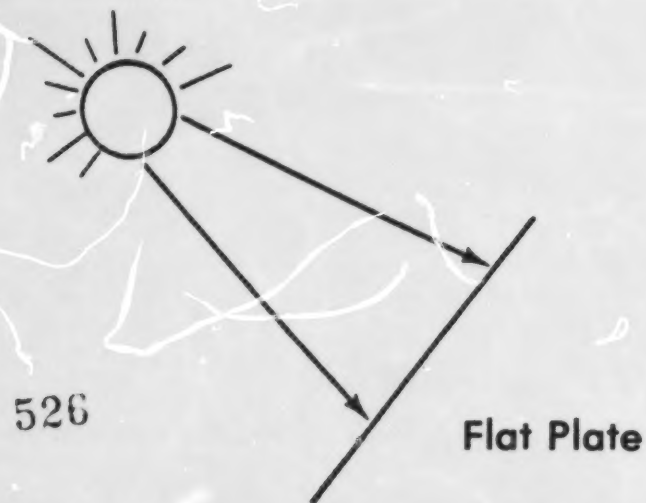
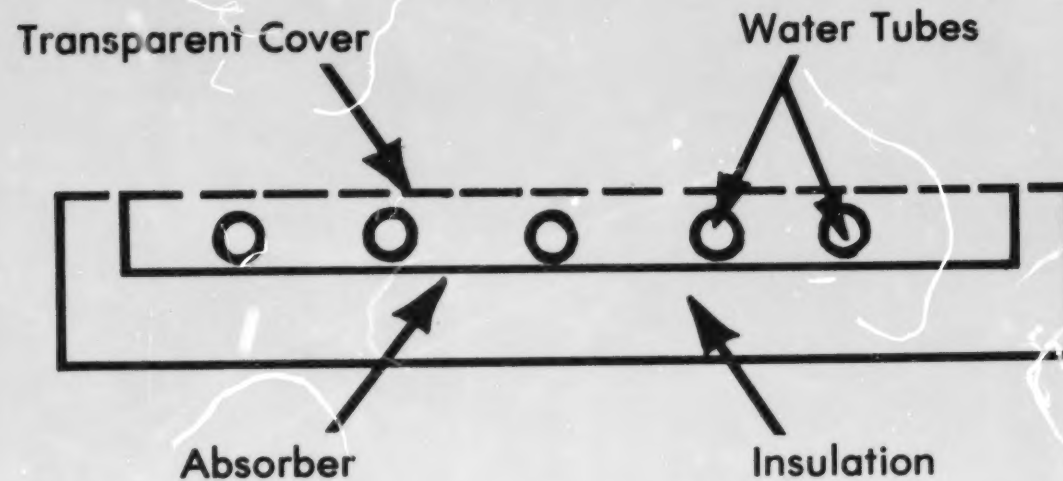
UNIT - ALTERNATE ENERGY SYSTEMS

Lesson 4 - What are active solar systems and their concepts?

EXAM

1. Name the two types of liquid systems.
 - a.
 - b.
2. Name the two types of collectors used for heat gain.
 - a.
 - b.
3. For maximum collector gain, the collector tilt angle should be within _____ to _____ degrees of the site latitude with respect to the sun.

Water Collector and Concentrators

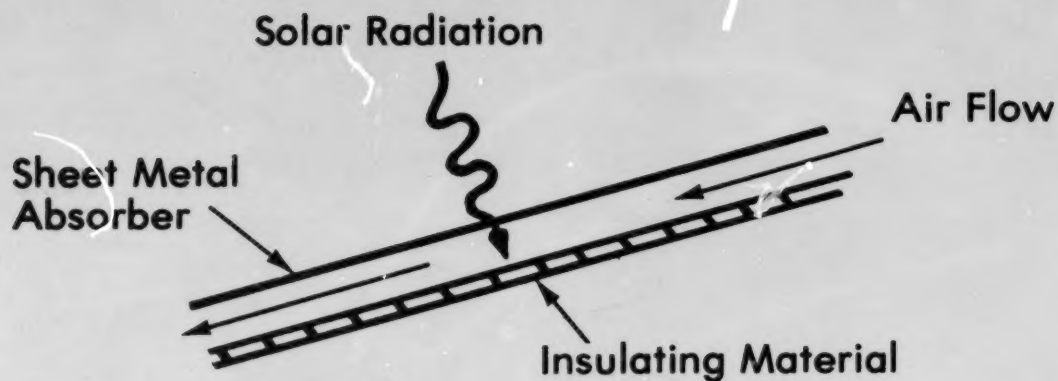


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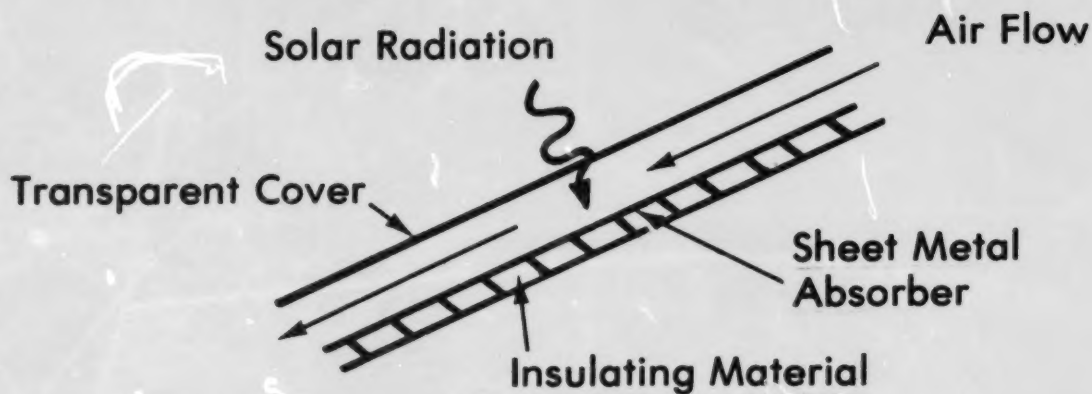
TW-1

Air Collector

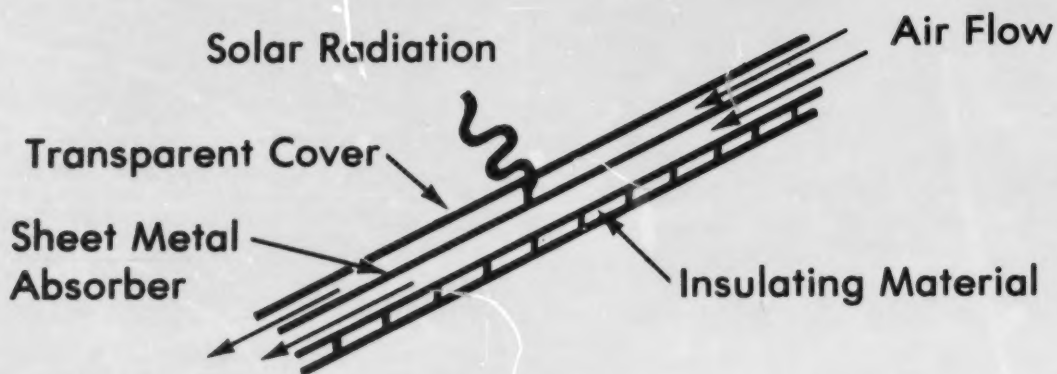
TM-2



Bare-Plate Type Solar Collector



Cover-Plate Type Solar Collector



Covered, Suspended-Plate Type Solar Collector

Efficiencies and Absorption

Table 1. Collection Efficiencies for Flat Plate Collectors.

Type	Day Long Efficiency
plastic tube type	25 percent
bare plate	30 percent
covered plate	35 percent
suspended plate	40 percent
2-covered suspended plate	45 percent

Table 2. Radiant Energy Absorption and Emittance for Several Surface Materials.

Material	Solar Absorption	Infrared Emittance
flat black paint	.97 - .99	.97 - .99
concrete and stone, dark colored paints, brick	.65 - .80	.85 - .95
light brick, light colored paints, firebrick, clay	.50 - .70	.85 - .95
glass	.04 - .4	.90
aluminum paint (bright)	.3 - .5	.4 - .6
dull brass, copper, galv. steel, aluminum	.4 - .65	.2 - .3
selective surfaces		
white paint	.23 - .49	
copper treated with NaClO_2 and NaOH	.87	.13
copper, aluminum, or nickel plate with CuO coating	.08 - .93	.09 - .21

Alternate Energy

HO-2

Design Tips

Bare plate collectors:

- Design temperature rise through collector: 10°F or less.

Maximum air velocity in collector: less than 750 feet per minute.

Minimum air space dimension: $\frac{3}{4}$ inch.

Material acceptable for collector: black or dark colored plastic sheeting, sheet metal.

Covered plate collectors:

Design temperature rise through collector: 50-75°F maximum.

Maximum air velocity in collector: less than 750 feet per minute.

Minimum air space dimension: $\frac{3}{4}$ inch.

Absorber materials acceptable: dark colored metal plates, dark wood surfaces.

Cover materials: low iron content glass, ultraviolet-resistant plastic sheeting, fiberglass-reinforced plastic with tedlar coating.

Double covers: use when design temperature in collector exceeds 75-80°F.

Insulation for sides and back of collector: $R = 13$ or greater.

Liquids for heat transfer:

Protect from freezing if required. Ethylene glycol can be used for freeze protection in closed systems.

If fluid has boiling point below 300°F, provide pressure relief valve in system.

Design friction head loss: less than five to six feet.

UNIT - ALTERNATE ENERGY SYSTEMS

Lesson 5 - What are some other sources of energy for the farm structures?

Objective: By the conclusion of the lesson, the student will be able to identify the parts needed, efficiency and applicability of alternate energy systems.

Study Questions:

1. When is wind power a good energy substitute for conventional power?
2. When is home-generated water power practical for the farm?
3. What application does wood power have to the farm?
4. Develop a planning checklist for energy efficiency.

References:

1. Construction Building Trades Solar Energy Techniques,
IML, UMC

UNIT - ALTERNATE ENERGY SYSTEMS

Lesson 5 - What are some other sources of energy for the farm structure?

TEACHING PROCEDURE

- A. Review solar applications.
- B. Motivation - How many students still have a windmill on the farm? How can windmills be used? What about a water wheel to run a mill?
- C. Assignment - Find as many different energy sources as possible on their home farm. Include windmills, water wheels, wood stoves, corncobs, manure, etc.
- D. Supervised Study - Build scaled models of windmills and water wheels to show the use of these energy systems.
- E. Discussion

1. The power of the wind has been applied worldwide and is again becoming popular as an energy source.

When is wind power a good energy substitute for conventional power?

- 1) Windmills require a site that has turbulence free wind currents of over 10 mph.
- 2) Wind systems are designed to operate at maximum efficiency output with 25 mp wind speeds.
- 3) Windmill systems require four component parts, which are:
 - a) Propeller
 - b) Generator or alternator
 - c) Governor and voltage regulator
 - d) Some means of storage or immediate load.
- 4) Efficiency output is usually 40 to 45%.
- 5) A well-planned, efficient windmill can provide power, either AC or DC, for storage to last seven days with normal load.
- 6) The biggest consideration is the competitive cost of wind generated electricity as opposed to the utility company's rate.
 - a) Utility rates are now \$.06/kwh.
 - b) At maximum efficiency, windmills can generate electricity costing the owner/user \$.08/kwh.
 - c) Also installation costs of both systems should be figured for comparison.
- 7) Windmills vary in power efficiency according to the propeller design and all component parts forming either a mechanical or electrical load on the system.

2. Water power ran the mills that powered large factories many years ago. It is still used today but is hard to control for an even flow of power. Where water is available in quality this might be an alternative to think about.

When is home-generated water power practical for the farm?

- 1) The power a water source can produce is measured by three variables:
 - a) The head of the water; top surface current
 - b) The average flow of the water
 - c) The efficiency of the water system utilized.
- 2) Use of the Manning formula gives the output in kilowatt power with consideration of all three variables and a constant.
 - a) $kw = \frac{(a)(b)(c)}{708}$
 - b) a = head, b = average water flow, and c = efficiency rating of the water system.
- 3) The efficiency of a system will vary from 45% for an overshot water wheel to 62% for a turbine.
- 4) Most systems require damming of the water source for four reasons:
 - a) To provide maximum head
 - b) Get full use of water flow
 - c) Protect the plant from flood water by creating a bypass
 - d) To store water to conserve supply during the dryer periods.
- 5) Be aware of the legal water rights when planning to use this system.
- 6) Water systems are very expensive to build but once installed, the payback period is from 4 to 10 years and getting shorter as fossil fuel prices increase. (Large generating unit)

3. Wood heat for buildings has hit a new high because of its availability and newly found efficiency in heating units.

What application does wood power have to the farm?

- 1) There is ample supply of wood in America although certain species of higher quality are vanishing.
- 2) There are many types of wood heating systems available to the public:
 - a) Radiant systems
 - b) Circulator systems
 - c) Conventional fireplace systems with aesthetic appeal

- d) Steel stoves
- e) Cast-iron stoves
- 3) Conventional fireplaces lose 90% of generated heat up the flue and cause a draw of house heat to go with it.
- 4) Steel stoves often use cast iron or firebrick liners with thermostats to control even temperature radiation and wood burning temperatures.
- 5) Cast iron stoves are most efficient, have even burning without software, and retain heat for greatest amount of time.
- 6) The use of radiant type systems are good for homes with thermal mass for radiant storage.
- 7) The use of circulator systems are good for homes with wood framing and minimum insulation where air infiltration is greater.
- 8) All wood heating systems have one big disadvantage; during the first warming period of the flue, unburned wood gases chill and form liquid cresote deposits in the flue creating favorable conditions for chimney fires.
- 9) During the course of the winter, the average, well insulated home primarily heated with wood uses no more than 7 cords of wood and in most case only one if the home is also passively heated.
- 10) Denser woods make better heat generating fires.
- 11) The cost effectiveness of wood is high and getting higher.
 - a) Matching BTU for BTU output, wood at \$78.00/cord equals one third the cost of electric rate at \$.06/kwh.
 - b) Fossil fuel prices would match wood if oil cost \$.50/gallon with respect to a matched BTU output.
- 12) Wood heat has long been a standard for many people and with the energy crisis, it may become more popular especially to those who live or move to forested acreages.

- 4. After discussion on the alternatives summarize with the following planning checklist.

Develop a planning checklist for energy efficiency.

- 1) Floor plan traffic patterns are normal, and provide easy access to all major rooms.
- 2) All areas generating heat, like the kitchen, should be centrally located.
- 3) The least used rooms should be located on the north side of the structure if possible so that frequently used rooms get southern exposure of light and heat.

- 4) And the plan should be basically of the open format to allow for better light dispersion, ventilation, and heating.
- 5) The south side window volume should allow for maximum solar gain during the winter months.
- 6) The windows should be double or triple glazed.
- 7) The windows should provide for window treatment which insulates to the outside during the night and reflects during the day.
- 8) Skylighting with reflective materials can provide up to 70% in the earth contact home.
- 9) South facing windows should provide almost 100% of the light for the entire home during the day.
- 10) The use of fluorescent lighting rather than incandescent lighting will save on electricity and generate less heat.
- 11) Ventilation throughout the house must provide for maximum distribution of cooling within the structure, exhausting of attic temperatures, and even heating in the required months those systems are used.
- 12) The overhang should be well vented for attic temperatures and be of enough length to shade south facing windows in the summer and expose those windows to the sun in the winter.
 - a) As a general rule if your house is located above 40-degree latitude, make the overhang 4' to 4 1/2' in length.
 - b) If your house is located at less than 40 degrees, the overhang should be 3 1/2' to 4' in length.
 - c) Adjustable overhangs are also commercially available.
- 13) Passive or active or both concepts should be utilized whenever possible.
- 14) Make sure that your design meets all building codes and regulations where the structure is to be built.
- 15) Make sure your design meets your needs personally and that it is not changing your personal habits for compatibility with the design.

F. Summary

The use of wind and water power is not a new idea and could yield new innovations if the cost of convenience power sources continues to spiral upward. We need to look to new and old energy sources to reduce our dependence on fossil fuels.

6. Evaluation

Answers to the Exam

1. T
2. T
3. Y
4. T
5. F
6. T
7. T
8. F
9. F
10. T

UNIT - ALTERNATE ENERGY SYSTEMS

Lesson 5 - What are some other sources of energy for the farm structure?

EXAM

- T F 1. Windmills, to achieve maximum efficiency, need a 25 mph wind speed.
- T F 2. Windmill efficiency is only 40 to 45%.
- T F 3. The Manning formula is important in calculating the power of water.
- T F 4. Water power systems have an efficiency of 65% for a turbine generator.
- T F 5. Fireplaces have an efficiency of 50%.
- T F 6. The denser the wood the higher the heat output.
- T F 7. When planning the structure, locate heat generating rooms in the center of the building.
- T F 8. Fluorescent lighting should be used because it produces more heat than incandescent bulbs.
- T F 9. Single-glazed windows are best because of their heat holding capacity.
- T F 10. The most efficient stove type for wood burning is cast iron.

UNIT - ALTERNATE ENERGY SYSTEMS

Lesson 6 - How is methane gas generated from manure?

Objective: By the conclusion of the lesson, the student will understand the procedure for converting manure to methane gas.

Study Questions:

1. How is methane generated from manure?
2. What is the potential methane production of different manure types?
3. What are the parts of an anaerobic digester?
4. What are the advantages and disadvantages of methane gas production?

References:

1. "Generating Methane Gas From Manure," UMC Guide #1881

Transparencies:

1. TM #1: Methane Process
2. TM #2: Anaerobic Digester

Handouts:

1. HO #1: Gas Production
2. HO #2: Gas Needs

UNIT - ALTERNATE ENERGY SYSTEMS

Lesson 6 - How is methane gas generated from manure?

TEACHING PROCEDURE

A. Review

- B. Motivation - Where are the bubbles in a lagoon generated?
Did you know that the gas in these bubbles
is flammable?

C. Assignment

D. Supervised Study

E. Discussion

1. Methane shows promise because it can help the environment by breaking down wastes and produce energy. The problem is the high cost and delicate balance that must be maintained in a system. See TM #1.

How is methane generated from manure?

- 1) The process uses anaerobic digestion of wastes
 - 2) Complex organics are broken down by acid forming bacteria to volatile fatty acids (Step 1).
 - 3) The volatile fatty acids are broken down by methane forming bacteria to methane (CH_4) and carbon dioxide (CO_2). (Step 2).
 - 4) This environment must be rigidly controlled to maintain production. We will discuss later.
2. The amount of methane produced will vary with the type of manure added to the digester.

What is the potential methane production of different manure types?

- 1) The potential gas production is shown in HO #1.
- 2) The gas produced will be about 60 percent methane and 40 percent carbon dioxide.
- 3) Pure methane has heat value of 1000 BTU per cubic foot.
- 4) Mixture of CH_4 - CO_2 will have a heat value of 600 BTU.
- 5) Typically, one-third of production is needed to heat the digester.
- 6) Typical farm heat requirements are shown in HO #2.

3. The digester needs careful balancing to keep the bacteria balance at the correct level. This involves the use of a complex system to achieve maximum production. See TM #2.

What are the parts of an anaerobic digester?

- 1) Primary structure
 - a) Digestion tank - concrete
 - b) Core shaped base for sludge removal
 - c) Floating top with pressure control (optional)
 - d) Must be air tight
 - e) Mixing device to distribute wastes
 - f) Heat to maintain 95°F
 - 2) Preheater
 - 3) Holding tank
 - 4) Gas storage
 - 5) Special sludge handling pumps and pipes
4. With every system there are problems that must be overcome and controls that must be enforced to achieve maximum production.

What are the advantages and disadvantages of methane gas production?

- 1) Methane formers must have an oxygen free environment to work.
- 2) PH must be maintained at 6.8-7.4.
 - a) Use lime at start up or when slug loading
 - b) High alkalinity is better than acid.
- 3) Salts, heavy metals, ammonia and antibiotics are toxic to bacteria.
 - a) Can control heavy metals (copper, zinc, nickel) with sulfides
 - b) High nitrogen manure will form ammonia; be careful.
- 4) A mistake may take several months to correct.
- 5) Load continuously to insure a food supply for bacteria.
- 6) The gas needs to be used quickly because it is difficult to store, hard to liquify.
- 7) Heat output is low compared to other systems.

F. Summary

Some energy can be extracted from manure through anaerobic digestion. But this would likely comprise only a small fraction of the total energy needs of a typical farm. High investments in money and management along with difficulties in efficiently using methane make anaerobic digestion a questionable venture for most farmers. If energy and fertilizer shortages become more acute, and pollution regulations concerning odor become more strict,

methane generation may become a feasible process in waste management systems. Research is needed to reduce capital costs of methane generation systems and provide techniques for proper management of such systems.

G. Evaluation

Answers to the Exam

1. T
2. F
3. F
4. F
5. (See TM #2.)

UNIT - ALTERNATE ENERGY SYSTEMS

Lesson 6 - How is methane gas generated from manure?

EXAM

- T F 1. Methane production is a two-step process.
- T F 2. Methane will replace LP gas as the fuel of the future in less than two years.
- T F 3. The methane produced is pure and easily stored.
- T F 4. Anyone with an old storage container can easily build a methane digester and operate it efficiently.
5. Draw a methane digester system.

Methane Process

Complex
Organics

Acid
→
Formers

Volatile
Acids

(Step 1)

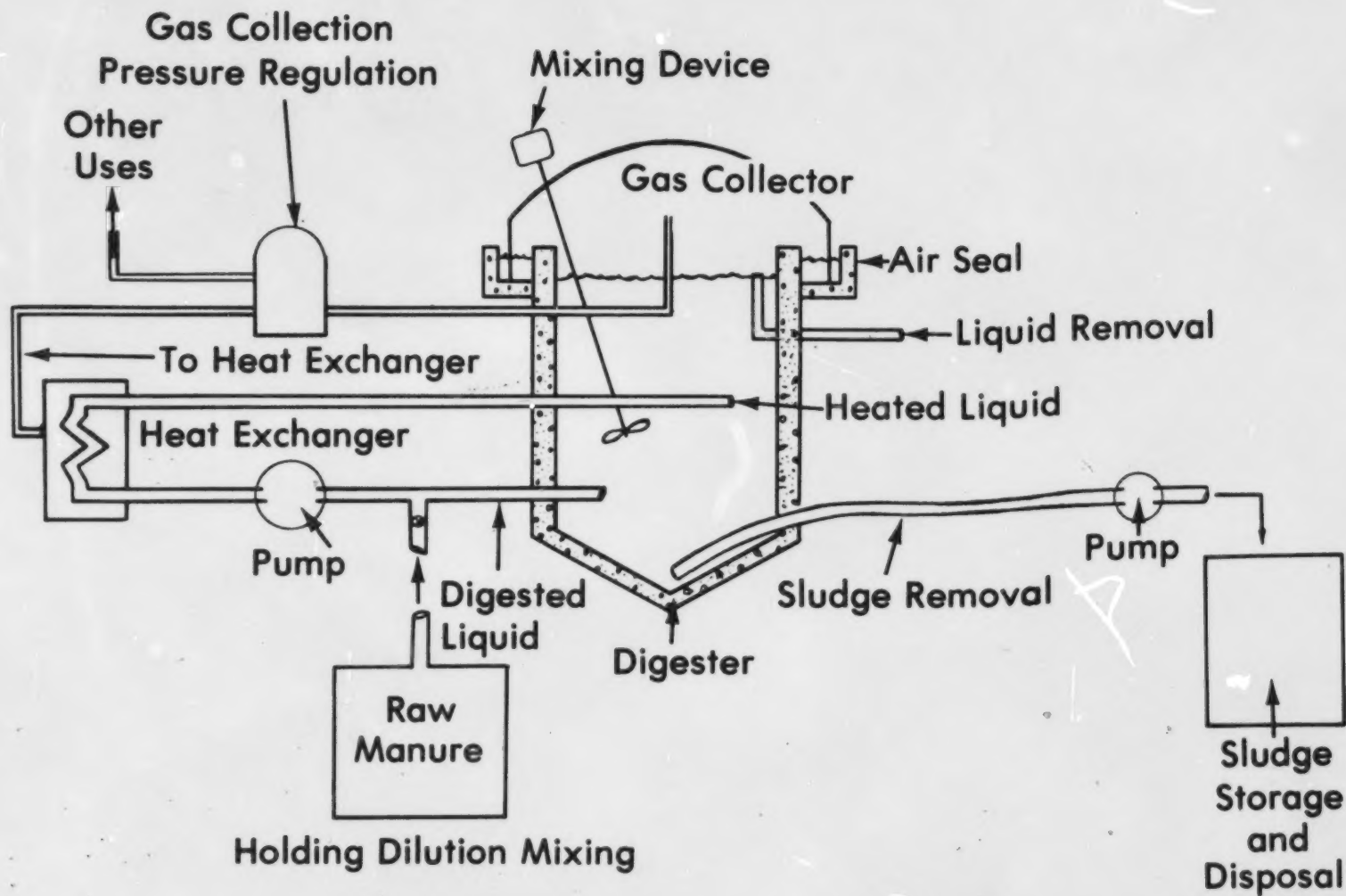
Volatile
Acids

Methane
→
Formers

$\text{CH}_4 + \text{CO}_2$

(Step 2)

Anaerobic Digester



733

545

546

TM-2

Gas Production

**Some Typical Farm Heat Requirements Are Numbers
Of Animals Required to Fulfill These Requirements**

	Heat Requirement BTU/hr	Swine 150 lb	Dairy 1200 lb	Poultry 4 lb bird	Beef 1000 lb
Kitchen range	65,000	77	14	1,547	11
Water Heater	45,000	107	20	2,143	15
Refrigerator	3,000	22	4	429	3
Heat 1500 sq. ft. home	37,500	535	99	10,714	72
In-bin grain drying heater	2,000,000	14,285	2631	285,714	1,923
50 hp tractor operating at full load	637,000	4,550	838	91,000	612

Assumed to operate 2 hr/da. i.e., a 24 hr average of 5417 BTU/hr

Assumed to operate 4 hr/da. 24 hr average = 7500 BTU/hr

Assumed to operate 12 hr/da. 24 hr average = 1500 BTU/hr

Assumed 25 BTU/hr/sq. ft. heat requirement

Assumed to operate 12 hr/da. during drying season, 24 hr average = 1,000,000 BTU/hr

Assumed to operate 12 hr/da. 24 hr average = 318,500 BTU/hr

Loading Rates, Detention Time, and Digester Volume for Swine, Dairy, Poultry and Beef

	Swine	Dairy	Poultry	Beef
Loading rate, lb volatile solids per cu. ft. digester volume per day	0.14	0.37	0.12	0.37
Detention time, days	12.5	17.5	10.	12.5
Digester volume, cu. ft./animal	5.0	26.	0.37	13.5
Digester volume for a typical livestock operation cu. ft./gallons	2500/20,000	1950/15,000	5550/42,000	4050/30,400
Swine-500 head				
Dairy-75 head				
Poultry-15,000 birds				
Beef-300 head				

Gas Needs

Potential Gas Production of Swine, Dairy, Poultry, and Beef

	Swine 150 lb	Dairy 1200 lb	Poultry 4 lb bird	Beef 1000 lb
Gas yield, cu. ft. per lb volatile solids destroyed	12	7.7	8.6	15
Volatile solids voided, lb/day	0.7	9.5	0.044	5.0
Percent reduction of volatile solids	49	31	56	41
Potential gas produc- tion cu. ft. per animal unit per day	4.1	22.7	0.21	31
Energy production rate. BTU/hr/animal	103	568	5.25	775
Available energy BTU/hr (after heating digester)	70	380	3.5	520

UNIT - ALTERNATE ENERGY SYSTEMS

ASSIGNMENT SHEET

Objective: By the conclusion of the lesson, the student will be able to identify current energy sources, look at their present situation, and identify future untapped energy sources.

Reference:

1. Understanding Solar Energy Systems, Laurie Keaton and Everett Edington. Wisconsin Vocational Studies Center, University of Wisconsin, Madison. 1978 edition.

Directions for Use:

The following two exercises can be used in the classroom situation or as a home project. The materials needed can be found in most homes. If used in class, divide the class into study groups of five or less; complete the activities; and answer the questions at the end of the assignment. If used as a home assignment, have the students run a ten-day trial plotting the temperatures on a graph, comparing, and then discussing possible differences.

EXERCISE 1

Materials Needed:

1. Two cans with covers
2. Black paint
3. Four glass jars. Size is important. Each can must fit inside one jar which will in turn fit inside the second jar.
4. Thermometer

Procedure:

- Step 1: Paint one can black and allow paint to dry.
- Step 2: Fill both cans with water and seal.
- Step 3: Place a can inside each of the smaller jars.
- Step 4: Lay the jars on their side where the direct rays of the sun will strike the jars.
- Step 5: After approximately 20 minutes (depending on the size of the containers) read and record the water temperature in each can.
- Step 6: Repeat the activity, but this time, place each can and jar inside the second glass container and wait for approximately 20 minutes before reading the temperature of the water.
- Step 7: Leave these "collectors" where the direct rays from the sun will strike the containers for about one hour. Read and record the temperatures again.

What Has Been Learned?

1. What temperature differences were observed?
2. How could higher temperatures have been obtained (consider using insulation and reflectors)?
3. Can you explain why a difference in temperature was observed when two glass containers were used instead of one?

EXERCISE 2

Materials Needed:

1. A 2' x 4' rectangular box with sides approximately 4" high.
2. Insulation
3. Black paint
4. Transparent glass or plastic cover
5. A large quantity of cans of the same size; beer cans or vegetable cans would be excellent.
6. Hole cutter
7. Can opener
8. Epoxy glue or caulking material
9. Thermometers

Procedure:

- Step 1: Make two 4 1/2-foot tubes by cutting off can lids and bottoms and gluing the cans together.
- Step 2: Remove one-half the lid and the bottom of each can. In this way, the movement of air through the tube will be impeded and more heat will be absorbed. Leave the lids at each end of the tube intact.
- Step 3: Paint the one tube black.
- Step 4: Place insulation in the bottom of the box.
- Step 5: Paint the surface of the insulation black.
- Step 6: Cut holes in either end of the box. Place cans in box so that the cans will protrude slightly at each end. Caulk around opening.
- Step 7: Cut 2-inch openings in each end of tube.
- Step 8: Place transparent cover over collector.
- Step 9: Tilt collector so that the flat, transparent surface is normal (perpendicular) to the direct rays of the sun. Be sure the holes in the tubes are not blocked.

Step 10: After approximately 30 minutes, check the temperature of the air entering the collector at the bottom and the air escaping at the top. Be careful to shade the thermometer when taking temperature readings.

What Has Been Learned?

1. Is there any difference in temperature between the air rising in the tubes which were painted black and those left unpainted?
2. Materials can be a serious problem in building collectors because the materials must withstand high temperatures and prolonged exposure to solar radiation. Plastics, caulks, adhesives, and paints are of especial importance. Where might one obtain information about materials?

APPENDICES

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APPENDIX A
ADDITIONAL SUPPLEMENTARY SOURCES

AG-15-S AGRICULTURAL WIRING HANDBOOK
VE-19-S WIRING SIMPLIFIED
VE-46-I NATIONAL ELECTRICAL CODE BOOK
VE-5-I BASIC ELECTRICITY
VE-5-S BASIC ELECTRICITY
IE-48-I RESIDENTIAL WIRING
IE-48-S RESIDENTIAL WIRING
IE-48-T RESIDENTIAL WIRING
VE-303-S UNDERSTANDING ELECTRICITY AND ELECTRICAL TERMS
VE-303- / UNDERSTANDING ELECTRICITY AND ELECTRICAL TERMS
VE-303-M UNDERSTANDING ELECTRICITY AND ELECTRICAL TERMS
VE-300-S HOW ELECTRIC MOTORS START AND RUN
VE-300-AV HOW ELECTRIC MOTORS START AND RUN
VE-302-S ELECTRIC MOTORS--SELECTION, PROTECTION, DRIVES
VE-302-SW ELECTRIC MOTORS--SELECTION, PROTECTION, DRIVES
VE-302-I ELECTRIC MOTORS--SELECTION, PROTECTION, DRIVES
VE-302-V ELECTRIC MOTORS--SELECTION, PROTECTION, DRIVES
VE-302-T ELECTRIC MOTORS--SELECTION, PROTECTION, DRIVES
VE-304-S ELECTRIC ENERGY
VE-304-AV ELECTRIC ENERGY
VE-305-S ELECTRIC WIRING--RESIDENTIAL-UTILITY BUILDINGS AND
SERVICE AREAS
VE-305-SW ELECTRIC WIRING--RESIDENTIAL-UTILITY BUILDINGS AND
SERVICE AREAS
VE-305-I ELECTRIC WIRING--RESIDENTIAL-UTILITY BUILDINGS AND
SERVICE AREAS
VE-305-AV ELECTRIC WIRING AUDIO VISUAL

VE-301-S MAINTAINING THE LIGHTING AND WIRING SYSTEM
VE-301-V MAINTAINING THE LIGHTING AND WIRING SYSTEM
VE-301-M MAINTAINING THE LIGHTING AND WIRING SYSTEM

The curriculum guides above can be ordered from:

Instructional Materials Laboratory
10 Industrial Education Building
University of South Carolina
Columbia, SC
(314) 882-2883

APPENDIX B

"Electrical Work Unit," Agricultural Structures II has been cross-indexed with the revised edition of Practical Farm Wiring Demonstrations written by Curtis Weston.

"Electrical Work Unit" Agricultural Structures II

Practical Farm Wiring Demonstrations

Lesson

Section

1

I - B, C, D, F

2

3

I - G, H, I

4

5

6

I - E

7

I - A, G

8

9

#10

#11

#III - A-E

#12

#13

I - A, E

II - A

#III - A-E

#14

I - A, E